The Journal of The American Society of Mechanical Engineers

January · 1915

DO YOU KNOW

That for years the Society has been and is serving the profession and each individual member in many ways, among them the following:—

An Employment Bureau is constantly assisting the members by placing them in positions where there is opportunity for advancement. Obviously it serves equally firms desiring competent men in any specialty.

Researches. The Library of the Society maintains a bureau of general information. Searches in every branch of technical literature, abstracts and translations, as well as photographic copies of articles and illustrations, are made at the request of members, by a trained staff. *A mail service* is maintained to furnish members at a distance just as adequate information as those who visit the library.

Rooms for private consultation are available and all members are invited to make their headquarters here when in New York.

Working alcoves, stationery, stenographers, and dictating machines are available for the use of members.

Forwarding Mail. Many out-of-town members now have their mail addressed in care of the Society.

A Register is maintained.

(*a*) showing every member of the Society from the beginning, also all who ever applied for membership, together with training, experience, specialties and references.

(*b*) a separate register classified according to specialties.

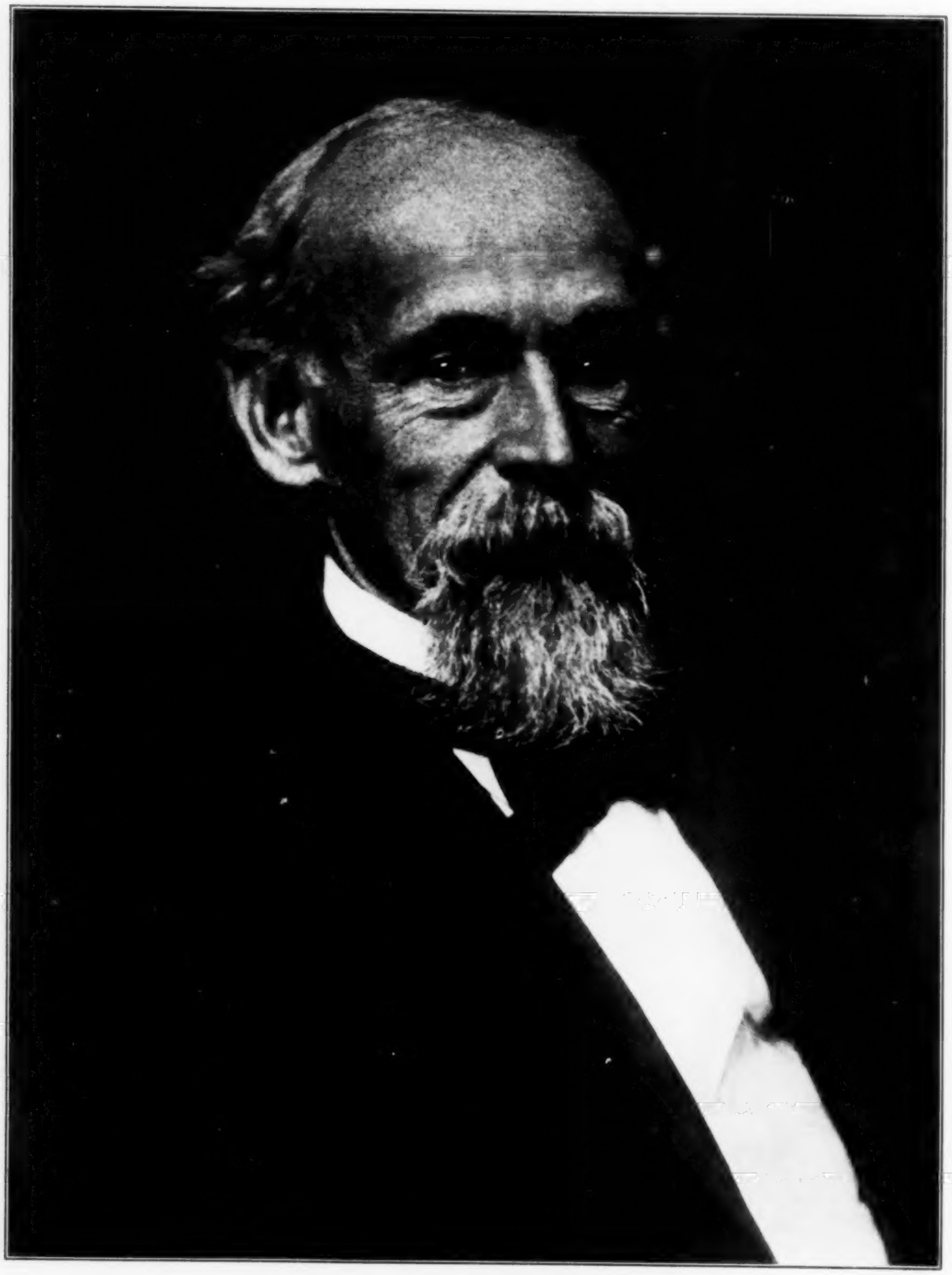
(*c*) a separate register indicating members according to companies.

This register is open to all members and is constantly consulted by them.

These are a few of the many valuable items of service rendered to the membership.

Visitors are always welcome.

Total Membership of the Society, December 28, 1914 6109
New Members since January 1, 1914 949



JOHN A. BRASHEAR

PRESIDENT 1915

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

THE JOURNAL OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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JOHN A. BRASHEAR

President of the Society for 1915

John A. Brashear was born in Brownsville, Pa., November 24, 1840. His father was a saddler, his mother the daughter of Nathaniel Smith, from whom young Brashear inherited his taste for science and mechanics, the grandfather having constructed one of the first telegraphic instruments made in Western Pennsylvania, and also succeeded in taking some of the earliest daguerreotypes.

The grandfather had a great love for astronomy and taught the constellations to his grandson when he was only eight years of age. About this time he had an opportunity to see the moon and Saturn through a small telescope made by a watchmaker of McKeesport, Pa., which had been brought to Brownsville, a small charge being made for the view. This left an indelible impression on the mind of young Brashear, and even at this early age he had a desire to own a telescope some day, perhaps, in the far distant future.

His education was confined to the common schools of Brownsville, but he found in his last two teachers men of large brains and a love for their calling, which made the little red brick school-house to him a real college and his only alma mater.

At 17 he was apprenticed to the patternmaking and engine-building trade at the works of John Snowden & Sons, and after finishing his trade, went to Louisville, Ky., where he engaged in engine-building with the firm of Dennis Long & Company.

While he was in Louisville the Civil War broke out and he came to Pittsburgh, where he took charge of the machinery of the Zug & Painter mill in 1862. In 1867 he was asked to take charge of the machinery in McKnight, Duncan & Company's mill, which he entirely rebuilt after a destructive fire. During his stay at this mill, Dr. George Barker of the University of Pennsylvania came to Pittsburgh to give a course of lectures on the spectrum analysis, a science then in its childhood, which Mr. Brashear heard, and as a result of which became so deeply interested in the subject that it was not long until he constructed a bisulphide of carbon prism and began the study himself.

After seven years with McKnight, Duncan & Company, his old friend Christopher Zug asked him to come to his mill again. The offer was accepted and he remained with the firm of Zug & Company until 1881, when he yielded to his great desire to construct astronomical instruments for amateurs, particularly in the line of silvered glass reflecting telescopes, which had not yet been made in this country except by Dr. Henry Draper, and decided to leave the rolling mill for good.

In 1862 Brashear married Phœbe Stewart, who was his faithful and devoted helpmate in all his early and later work, and the husband and wife spent three years making their first lens and constructing a 5-in. refractor. When this did not prove very satisfactory, they undertook a 12-in. reflecting telescope, the glass of which was broken by accident after two years of night labor, for all this work was done during Mr. Brashear's stay in the rolling mill.

Nothing daunted, the good wife had everything made ready in the little workshop the day after the accident, and in two months a new 12-in. telescope was ready for observation, and was used for many years in a study of celestial phenomena, including the question of changes on the moon's surface, comets and nebulæ, for which the 12-in. telescope was particularly well suited.

Professor Langley early became interested in Mr. Brashear's work and entrusted him with a number of important pieces of apparatus, among them his accurate mirrors, solar storage energy apparatus, etc. At the time Professor Langley was making his study of the selective absorption of the earth's atmosphere and its relation to organic life upon the earth, he required accurate rock salt lenses and prisms, which had not been made with the precision demanded until the problem was solved by Mr. Brashear. The method was given to the scientific world in a paper read before the American Association of Science about 1885. Langley's memorable researches in this great field made him famous, and he never failed to give Mr. Brashear a fair share of the credit of making his discoveries possible.

Mr. William Thaw, the Pittsburgh philanthropist and a friend of Langley's, sent for Brashear, and insisted upon building him a better workshop, finally in-

ducing him to move to Allegheny, so as to be near the observatory. Here began a lasting friendship with Mr. Thaw and Professor Langley. For three years all the early experimental equipment for Langley's researches in aviation, ærodynamics and ærodromics was made in the Brashear laboratory.

Orders began to come in to the new workshop, especially in the line of spectroscopes, and about this time Professor Rowland of Johns Hopkins University, entrusted Mr. Brashear with the making of the delicate plates on which he was to rule his wonderful diffraction gratings.

About this time Mr. Brashear's daughter married Mr. McDowell, who at once joined in the work, soon proving himself to be a master in the production of accurate optical surfaces. Brashear has always given the largest share of credit to Mr. McDowell, his associate, who has succeeded in reaching the highest demands of modern research, in optical lines.

Dr. Charles Hastings of Yale University early became associated with the firm, and with his mastery of mathematical optics, computed the curves of many object glasses of the highest type, doing away with all empiricism. The last large objective computed by him, and only recently finished by Mr. McDowell, is the 30-in. glass for the Allegheny Observatory, which is said to be the most perfect glass in the world today. The mountings of many of the larger telescopes were constructed by Messrs. Warner and Swasey, Past-Presidents of the Society.

Spectroscopes of every description for research have been made in Mr. Brashear's shop for institutions all over the world, for both astronomical and physical research, spectroheliographs, for studies of the sun; indeed, such has been the progress of astronomical spectroscopy since the Brashear works turned out the first spectroscope for Professor Keeler, for use with the great telescope of the Lick observatory, that it seems a new science, and remarkable discoveries in celestial physics are coming to us every day. Putting the matter grossly, the Keeler spectroscope was thought to be over heavy, as it weighed 45 lb. The Porter spectroscope, made for the Allegheny Observatory, weighs nearly nine tons, with its counterpoises, etc.

The development of the astronomical photographic camera has been carried along as one of the principal features of the Brashear works. The double camera of the 40 centimeter photographic telescope of the Heidelberg Observatory is one of the products of the firm and is the handiwork of Mr. McDowell, whose skill and judgment were equal to any optical task, but who was unwilling to pass any work of precision without the final criticism of Mr. Brashear.

The delicate plane parallel mirrors made for the study of the International Standard Meter in terms of light waves, were made by Mr. McDowell, and were used with the Interferometer devised by Dr. Michelson, for whom the surfaces were made. The Standard Meter has now an absolute value in something that can never be destroyed. The limiting error of these delicate surfaces was less than $^1/_{200,000}$ in., such is the precision demanded in modern scientific research.

Mr. Brashear early became interested in educational work, beginning among his fellow workmen in the rolling mill. He has given over five hundred lectures to working men's organizations, indeed, to all classes of citizens interested in the beauties of science. He has personally known most of the eminent men in science of the last forty years, has served as acting chancellor of the University of Pittsburgh, as acting director of the Allegheny Observatory, and has been a member of the Board of Trustees of the Carnegie Institute since its beginning, and also of the Carnegie Technical Schools, the University of Pittsburgh, and is chairman of the Observatory Committee, as well as of several other institutions of an educational character.

Five years ago he was entrusted with a fund of $250,000 by a friend of education, for the betterment of teaching and teachers in the public schools of Pittsburgh. Forming a commission to assist him in carrying out the donor's wishes, 605 teachers have been sent to summer schools from Maine to California for study, rest and recreation, and the results have been invaluable.

Mr. Brashear was also for many years interested in another project for helpfulness, the building and equipping of an astronomical observatory as a memorial to Mr. Thaw and his son, and to Professor Langley's lifelong friend, Professor Keeler. For this institution $300,000 was raised, which is now one of the finest and best equipped observatories in the world. Through Mr. Brashear's efforts one department in the new observatory is free, and in the five years it has been open to the public no less than 14,500 people have made use of the telescope or listened to lectures on astronomy. Under the dome of one of the memorial telescopes, a mausoleum has been constructed by the friends of Mr. Brashear and Professor Keeler, in which lie the ashes of Professor Keeler and also those of Mrs. Brashear, who passed away in 1910. On the tablet covering the ashes of Mrs. Brashear are the words: "We have loved the stars too fondly to be fearful of the night."

Mr. Brashear was elected an Honorary Member of this Society in 1908. He is also an Honorary Member and Past-President of the Engineers Society of Western Pennsylvania and of the Royal Astronomical Society of Canada, an active member of the Royal Astronomical Society of Great Britain, the British Astronomical Society, the Société Astronomique de France, the Société Astronomique de Belgique, the American Philosophical Society, the American Astronomical Society, the American Association for the Advancement of Science, the Academy of Science and Art, and others.

He received the gold medal of the Franklin Insti-

tute in 1910; the degree of LL.D. from Washington and Jefferson, and Wooster Universities, the degree of D.Sc. from Princeton and the University of Pittsburgh, and that of Doctor of Engineering from Stevens Institute of Technology.

THE ENGINEERING FOUNDATION

A noteworthy incident in the history of the profession of engineering in the United States will be the inauguration of The Engineering Foundation on January 27, 1915, in the auditorium of the United Engineering Society in New York.

The Engineering Foundation is the name given to a fund to be administered for the advancement of the Arts and Sciences connected with Engineering and the benefit of Mankind, the basis of which is the initial gift of a considerable sum by a noted engineer for this purpose. The American Society of Civil Engineers, the American Institute of Mining Engineers, The American Society of Mechanical Engineers and the American Institute of Electrical Engineers are to be represented equally in the administrative Board of The Engineering Foundation by election by the Board of Trustees of the United Engineering Society, which had been made the custodian of the fund. All members and friends of the engineering profession are invited to these inaugural ceremonies.

SUGGESTIONS FOR AMENDMENT TO C-50 OF THE CONSTITUTION AND BY-LAWS

The following letter has been sent to the members of the Council:

December 18, 1914

To the Members of the Council
of The American Society of Mechanical Engineers
Gentlemen:

At meetings of the Council held November 13 and December 1, 1914, the following resolutions were passed:

Resolved: That it is the sense of the Council that the present method of nominating officers of the Society be amended, and request the Committee on Constitution and By-Laws to prepare such amendments to the Constitution and By-Laws as may be necessary in order to permit members to express their choice for nominees.

Constitution and By-Laws

Voted: That members of the present Council be requested to file with the Secretary for reference to the Council and Committee on Constitution and By-Laws, suggestions concerning any needed changes in the Constitution and By-Laws.

Under this action of the Council will you kindly send to the Secretary of the Society to be transmitted to the Committee on Constitution and By-Laws any suggestions which you would like to have considered by the Committee.

You would greatly facilitate the work of the Committee if we could have your suggestions in the hands of the Committee before January 20.

Yours very truly,
Calvin W. Rice, *Secretary.*

COUNCIL NOTES

December 1

At a meeting of the Council on December 1 a committee was appointed by the President to report at the next meeting suggestions as to the Local Meetings of the Society. This Committee consisted of F. R. Hutton, Chairman, A. M. Greene, H. G. Stott and W. F. M. Goss.

The following appointments of Honorary Vice-Presidents were confirmed: Annual Meeting of the American Society of Refrigerating Engineers, Dr. Chas. E. Lucke; Pan-American Scientific Congress, committee to coöperate with the Department of State, General Wm. H. Bixby, Chas. T. Plunkett, and the Secretary.

The report of the Committee of the John Fitch Memorial was received and placed on file.

The matter of the bequest of Rear-Admiral Melville which provides for the Melville prize medal for original work was referred to the Finance Committee.

It was voted to authorize the President to coöperate with the American Institute of Mining Engineers and to make appointments on a joint committee on turbo-blowers.

December 4

At a meeting of the Council on December 4, the new officers were formally introduced.

It was voted that, in accordance with resolutions adopted by the committee appointed to consider and report on Local Meetings of the Society, a Committee on Sections, consisting of five members, be appointed by the Council which shall confer with the various sections and promote their interests.

In this Society it has always been customary to elect as officers of the Society and to appoint as members of committees the most eminent men in the profession, with the definite understanding that the actual labor of the committee shall be performed by the Secretary and a competent staff.

This is in distinction from all other societies which have succeeded in getting sufficiently able and representative men who not only have served on the board and committees, but themselves have performed the work or had it done without expense to the society.

In order to insure that what is done may be performed as efficiently as possible, it was voted that a committee, to be known as the Committee on Administration, be appointed, to investigate and report upon the economical operation of the Society's administration.

It is to be hoped that as time goes on the members will feel that they owe it to their profession to give their services to such an extent that they shall personally undertake the duties of the various committees on which they are appointed and thus perform the work better than any one that can be employed, and in the discussions on the meetings of the Society the em-

phasis will be on the thing to be accomplished and not on its cost.

John R. Freeman was appointed a member of the Board of Trustees of the United Engineering Society, to succeed Fred J. Miller, whose term of office has expired and who, having served one term, was under the Constitution not eligible for re-election.

Dr. John A. Brashear was reappointed to succeed himself as representative on the John Fritz Medal Board of Award, to serve for a term of four years.

It was voted that the Publication Committee be requested to prepare a circular regarding the form of publication of The Journal and the continuance of the publication of the Transactions in its present form, to be submitted to the membership for letter ballot in accordance with the vote of the Annual Meeting.

The following Executive Committee of the Council was appointed for 1915: John A. Brashear, President, Chairman; H. L. Gantt, Vice-Chairman; A. M. Greene, Jr.; Henry Hess; Spencer Miller; H. G. Reist; and James R. Sague.

Calvin W. Rice, *Secretary*.

BOILER INSPECTION IN RUSSIA

In connection with the work of the Committee on Boiler Specifications, a statement secured by the editor of the Foreign Review of boiler inspection in Russia is of interest. The main work of boiler inspection is concentrated in the hands of the Ministry of Manufactures which carries it on through its factory inspectors. As the main work of the factory inspection in that country is concerned with the supervision of the proper application of the rather complicated and strict labor laws, there has been a feeling for a long time that it would be best to select the inspectors from men who had had training in legal and economic questions, but the fact that the inspectors had to inspect the boiler equipment of factories limited their selection to graduates of engineering schools exclusively. As a result, a law has been recently worked out for referring the entire matter of boiler inspection to Boiler Inspection Associations, which are private organizations, but which operate under government supervision.

At the same time, there is a pronounced tendency to make the boiler inspection laws more uniform than they have been hitherto. While the laws generally extended to the entire country, there has been a certain lack of uniformity due to the fact that certain plants have been under the supervision of the Ministry of the Interior, and others, especially boiler plants on river and canal steamers, under that of the Ministry of Ways of Communication, these two ministries often promulgating regulations different from those of the Ministry of Manufactures, which governed the inspection in the majority of factories. The regulations published by the Ministry of Ways of Communication in 1913 for "the installation and testing of boiler and steam piping on vessels on internal waterways," are in closer agreement with the rules of factory boiler inspection than have been the case hitherto, and it is expected that, as soon as the war is over, a uniform boiler code will be adopted for the entire country.

GREETINGS FROM DR. BRASHEAR

It was a pleasure to receive at the Christmas season a telegram containing greetings from President Brashear, and through the medium of The Journal these are extended to the membership at large. The telegram reads as follows:

Dear Mr. Rice:

May I send through you my most kindly Christmas greetings to every member of the A.S.M.E. and all affiliated societies, wishing them health, happiness and prosperity, and may all have an ever present spirit of helpfulness in the great work, but pushing outward the borders of human knowledge.

Always cordially yours,
John Alfred Brashear,
Member of the Other Fellows Club

A STUDENT BRANCH CONFERENCE

During the Annual Meeting of the Society in December a conference was held on the subject of the Student Branches of the Society. Prof. F. R. Hutton, Chairman of the Committee, presided. The interchange of experience and discussion of the differing problems of each institution was thought of such value that it was decided that a similar conference should be made part of the program of every Annual Meeting:

The topics broached covered:

(1) The advisability of having the Society office notify each member of a branch of his election to such membership

(2) The advantage of a diploma or certificate of membership; or of a button or lapel-badge

(3) The difficulties when Seniors only were members of a student branch in a transmittal of an èsprit de corps to the succeeding class

(4) The possibilities of using The Journal of the Society in seminar work of teaching

(5) The advantage of beginning an academic (and a branch) year by a social meeting at which also some outside engineer should speak and refreshments be a feature

(6) The advantages of stimulating participation of the student himself by paper and by discussion, even if the plan of getting talent from outside had to be curtailed to accomplish this result. Case School accepts papers presented before the branch as equivalent to required work for the degree, when of satisfactory quality

(7) The ideal (of Brooklyn Polytechnic Branch) of making the branch tell both for the engineering education of the members and for their so-

cial intercourse and their becoming "experts in friendship"

(8) The use of the stimulus of prizes for student papers before the branch (Hess Prizes) in promoting research work in laboratory or library and outside of the required curriculum for the degree

(9) Query raised: Does the requirement of a $2 subscription for the A.S.M.E. Journal keep any man from joining a Student Branch?

(10) Can students in course be members of the branch organization without paying a $2 Journal subscription?

(11) Suggestion offered: That one address per year by an A.S.M.E. member of experience be a feature of branch life; that a booklet covering the advantages of membership in a Student Branch be prepared by the Society, and it be made the duty of the professor who is honorary president of the branch to see each spring that these get into the hands of the class becoming eligible to membership; that lower classmen be always invited to branch meetings, while right to office and to vote be prerogatives of the upper classmen.

(12) One institution has a society of students for each year, the topics being chosen and pursued with some regard to the advancement in the course of study. The senior society becomes the A.S.M.E. branch by promotion, and hence a pride is felt in the branch, because it has been looked forward to

(13) That the A.S.M.E. invite the Student Branches to send delegates as such to the Annual (or semi-annual) Meeting of the Society, such accredited delegates to have the rights of members in attendance

(14) That a reunion of such delegates and of the honorary chairman of the branches be a stated feature of Society conventions

(15) That a report and summary of the meeting be published in The Journal for the information of Student Branches and their officers.

(16) That the Student Branches are potentialities of great mutual service, to the men and to the Society

F. R. H.

JOURNAL ANNOUNCEMENT

During the past year The Journal has been made to include the Transactions of the Society, comprising papers and discussion given at the Annual and Spring Meetings and many of the papers given at local meetings of the Society. The Annual and Spring Meeting papers have been published in full, except in cases where they have been previously printed in earlier numbers of The Journal.

In the provision which has been made for binding, it was decided to include in the bound volume the papers and discussion mentioned above, and in addition the Review Section which contains abstracts of articles published in the foreign press and the proceedings of engineering societies. As announced elsewhere, covers for binding will be supplied for 75 cents. Any member ordering a cover may have the item charged to his account.

As announced in the December Journal, however, the Council has voted to continue the annual volume of Transactions in its original form in library binding for at least another year, so that members will receive in this volume as heretofore the papers and discussion given at the Annual and Spring Meetings, which will duplicate the reports of these meetings as published in The Journal. The additional matter in The Journal, which will not be contained in Transactions, consists of the monthly meeting papers and the abstracts of articles in the Review Section.

For the coming year, in view of the decision to publish Transactions as a separate volume, the papers and discussion will be printed in The Journal in abstract, as has been done in the present issue. The object will be to present to the membership in a brief and comprehensive form reports of meetings as soon as possible after they have taken place, so that it will not be necessary to wait until the end of the year before receiving this information.

All members are asked to give particular attention to this method of handling the publications of the Society, as in accordance with the resolution adopted at the Annual Meeting they will be asked to express their preference in the near future.

APPLICATIONS FOR MEMBERSHIP

Members are requested to scrutinize with the utmost care the following list of candidates who have filed applications for membership in the Society. These are subdivided according to the grades for which their age would qualify them and not with regard to professional qualifications, i. e., the age of those under the first heading would place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, while those in the third class are qualified for Junior grade only. The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into the Membership by advising the Secretary promptly of anyone whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential and is solely for the good of the Society, which it is the duty of every member to promote. These candidates will be balloted upon by the Council unless objection is received before February 10, 1915.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

Alrich, Herbert W., Asst. Engr. of Constr., Consolidated Gas Co., New York

Barden, Julius C., Assoc. Dir., Bureau of Inspection and Accident Prevention, Aetna Life Ins. Co., Hartford, Conn.

Barrett, William F., Cons. Engr., Chicago, Ill., and New York

Bean, Clarence H., Asst. Supt. Motor Pwr., Armour & Co., Chicago, Ill.

Blake, Frederick W., Genl. Mgr., United Railways of Yucatan, Yucatan, Mex.

Dadley, James W., Efficiency Engr., The Celluloid Co., Newark, N. J.

Dierman, William, Pur. Agt., Society of Electrical Lighting, Paris, France

Duff, Howard, First Asst. Chief, Testing Bureau, Brooklyn Rapid Transit Co., Brooklyn, N. Y.

Ferguson, Smith F., Cons. Engr., Nicholas S. Hill Jr., and S. F. Ferguson, New York

Ford, Henry, Pres., Ford Motor Co., Detroit, Mich.

Francis, Ira J., With John A. Roebling's Sons Co., Los Angeles, Cal.

Gilmore, Thomas N., Ch. Engr., Westinghouse Church Kerr & Co., New York

Hamilton, Henry A., Asst. Mgr., Mengel Box Co., Jersey City, N. J.

Hardy, Clement A., With Whiting Foundry Equipment Co., Harvey, Ill.

Hosford, William F., Engr. of Methods, Western Elec. Co., Chicago, Ill.

Kellogg, Raymond M., Asst. Engr., Gas Dept., Westchester, Ltg. Co., Mt. Vernon, N. Y.

Kennedy, James S., Supt., Standard Gas Light Co.'s Wks., New York

Larson, Gustus L., Prof. Mech Engrg., Univ. of Idaho, Moscow, Idaho.

Leach, Ralph W. E., New England Rep., American Engrg. Co., Boston, Mass.

Lemley, Benjamin W., Vice-Pres., Coats & Burchard Co., Chicago, Ill., and Supvg. Engr., Constr. Dept., General Elec. Co., Cleveland, Ohio

Loizeaux, Alfred S., Elec. Engr. and Supt of Constr., Consolidated Gas Elec. Lt. & Pwr. Co., Baltimore, Md.

Nixon, Boyd, Pacific Coast Rep., Eastern Mch. Tool Builders, Glassboro, N. J.

Platts, Charles A., Transportation Engr., Boston Branch, The Kelly-Springfield Motor Truck Co., Cambridge, Mass.

Quinn, Stephen M., Elec. Constr., Dodge Brothers, Detroit, Mich.

Roueche, William L., Supt. Pipe Shop, Crane Co., Birmingham, Ala.

Smith, Merrill Van G., Prof. of Mech. Engrg., Delaware College, Newark, Del.

Stone, William G., Whitesboro, N. Y.

Thompson, John L., Supvg. Engr., Travelers Ins. Co., & Travelers Indemnity Co., Hartford, Conn.

Whiton, Herbert S., Supt. Manuf., Minneapolis Genl. Elec. Co., Minneapolis, Minn.

Williams, Harold E., Vice-Pres., Railway Materials Export Corp., and Eastern Rep., Pyle-National Elec. Headlight Co., New York

Younger, John, Ch. Engr., Truck Dept., Pierce Arrow Motor Car Co., Buffalo, N. Y.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

Allen, J. Wallace, Asst. Ch. Engr., New Castle Wks., American Sheet & Tin Plate Co., New Castle, Pa.

Chesnutt, Ralph C., Ch. Designer, Aurora Automatic Mchy. Co., Chicago, Ill.

Clarkson, Ralph P., Prof. of Engrg., Acadia Univ., Wolfville, N. S., Canada

Coe, Harry L., Mech. Engr. and Mem. of Firm, Harpham, Barnes & Stevenson Co., Boston, Mass.

Dunton, Philip R., Supt. Municipal Water & Light Plant, Ponca City, Okla.

Eidmann, Frank L., Instr. Dept. of Mech. Engrg., Rensselaer Poly. Inst., Troy, N. Y.

Flack, Alonzo, With The Emerson Co., New York

Hale, Henry A., Jr., Mgr. Bureau of Safety, American Mut. Liability Ins. Co., Boston, Mass.

Hamilton, William P. B., Mech. Engr., Mengel Box Co., Jersey City, N. J.

Miller, Sereno G., Prin. Mech. and Engrg. Dept., New Bedford Textile School, New Bedford, Mass.

Pope, Joseph, Mem. Station Betterment Div., Stone & Webster Engrg. Corp., Boston, Mass.

Tillman, Richard H., Indus. Engr., Consolidated Gas, Elec. Lt. & Pwr. Co., Baltimore, Md.

FOR CONSIDERATION AS JUNIOR

Allison, Laurence M., Mech. Draftsman, Iola Portland Cement Co., Iola, Kan.

Gibbs, Paul H., Mech. Engr., Belknap Mfg. Co., Bridgeport, Conn.

Hassell, Hube, Machinist, Tennessee Central R. R. Co., Nashville, Tenn.

Henry, William M., Treas. and Engr. of Production, Henry & Allen, Auburn, N. Y.

Kroeschell, Robert A., Engrg. Dept., Kroeschell Bros. Ice Mch. Co., Chicago, Ill.

Leistner, August, Operator, Pwr. Plant, Hudson & Manhattan R. R. Co., Jersey City, N. J.

Link, Edgar W., Testing Dept., The Westinghouse Mch. Co., East Pittsburgh, Pa.

Lutze, Jay H., Designer, The Bristol Co., Waterbury, Conn.

Manker, Forrest W., With B. F. Sturtevant Co., Boston, Mass.

Maverick, Lewis A., Asst. Sales Mgr., Germania Refrigeration & Mchy. Co., Belleville, Ill.

Penniman, Abbott L., Jr., Supt. Steam Stations, Consolidated Gas, Elec. Lt. & Pwr. Co., Baltimore, Md.

Scriven, Albert K., Shop Foreman, Easton Mch. Co., South Easton, Mass.

Simon, Cecil S., Machinist, Drum Pwr. Plant, Pacific Gas & Elec. Co., San Francisco, Cal.

Smith, Peter M., Mech. Draftsman, The William Tod Co., Youngstown, Ohio.

Spofford, Harry H. R., With Schutte & Koerting Co., Philadelphia, Pa.

Thornhill, W. H. T., Estimator, Midvale Steel Co., Philadelphia, Pa.

Williams, Harold J., Instr. Applied Mechs., Pratt Inst., Brooklyn, N. Y.

Woolner, Seymour A., Pur. Agt., Woolner Distilling Co., Peoria, Ill.

APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM ASSOCIATE

Kruesi, August H., Engr. of Constr., General Elec. Co., Schenectady, N. Y.

PROMOTION FROM JUNIOR

Faile, Edward H., Supvg. Engr., Adams Express Bldg. Co., New York

Swarts, Guy T., Vice-Pres. and Ch. Engr., Steam Equipment Mfg. Co., Pittsburg, Pa.

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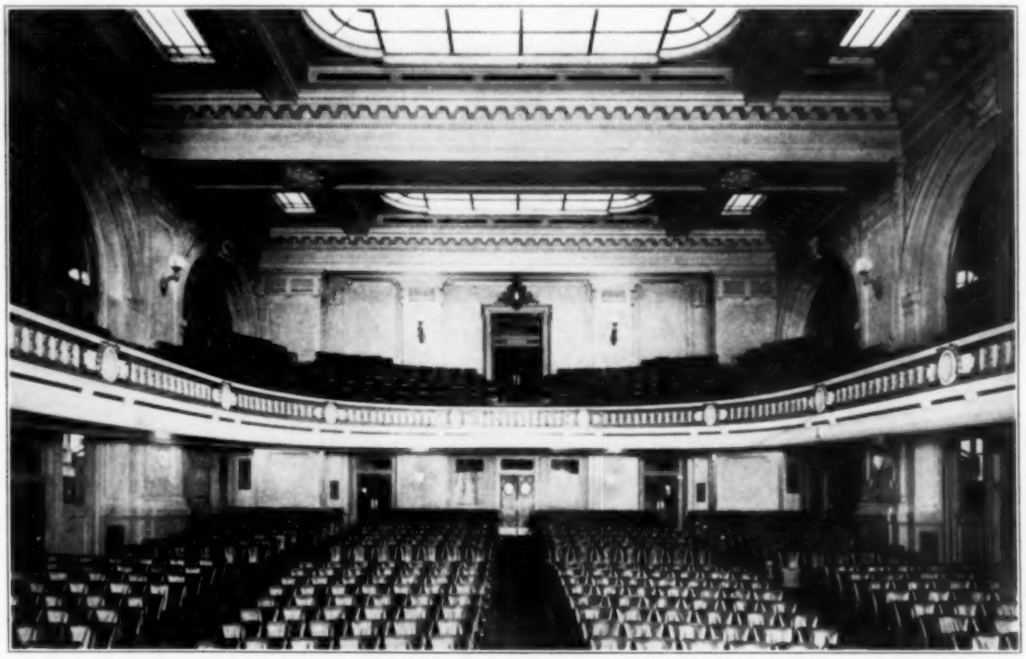
THE ANNUAL MEETING

HELD AT THE SOCIETY HEADQUARTERS, NEW YORK, DECEMBER 1—4

THIS meeting, which was one of the most successful in the history of the Society, was notable for the unusual number of papers devoted to many branches of engineering. Interesting papers were contributed on subjects in Industrial Engineering, Textiles, Machine Shop Practice, Railroad Engineering, Public Service, Iron and Steel, Hoisting and Conveying, Cement Manufacture, etc., and unusual interest was shown in all the sessions, of which there was a total of fifteen. One of the most important features of the meeting was the discussion of the Progress Report of the Boiler Specifications Committee, which occupied six sessions. The attendance at this meeting was the largest in the history of the Society.

The thirty-fifth Annual Meeting of the Society, held December 1-4, 1914, in the Engineering Societies Building, New York, was notable for its unusually large number of professional papers and technical sessions, and for the discussion of the preliminary report of the Boiler Code Committee, the latter alone extending through six sessions. In all a total of 27 papers were read, besides the address of President Hartness on Tuesday evening, and 15 sessions were held, including those on the Boiler Code, there being sometimes three simultaneous sessions under way, and on Thursday afternoon four were in progress at the same time. The papers covered a wide range of subjects and were effective in drawing a large audience. The attendance at the meeting was the largest in the history of the Society, the total registration being 1367, of which 821 were members.



Main Auditorium of the Engineering Societies Building where the Larger of the Professional Sessions are held

The social features of the meeting, under the supervision of the House Committee and the Committee on Meetings of the Society in New York, were attractive and well attended. The usual presidential reception was held in the Society rooms on Tuesday evening with a large attendance, and on Wednesday afternoon the rooms were the scene of a successful reception and thé dansant given by the Ladies' Committee, Mrs. Edward Van Winkle, Chairman. The chief social event came on Thursday evening at the Hotel Astor, where the annual reunion took the form of a dinner dance. More than 300 covers were laid in the grand ball room, the guests progressing from table to table for the various courses. There was dancing between courses as well as at the conclusion of the dinner. This dinner dance was an innovation which apparently was very pleasant to every one and many expressed the hope that it might be made a permanent feature of the Annual Meetings. Unlike the usual dinner or formal reception, it gave every person present an opportunity to meet a large number of others and the event pro-

moted sociability to the greatest possible degree. Another delightful occasion was the luncheon tendered to the ladies of the Society on Thursday in the Orangerie of the Hotel Astor by Mrs. Harrington Emerson, which was attended by about 125.

The presentation of the John Fritz Medal on Wednesday evening, together with the interesting addresses given by Dr. James Douglas, Honorary Member and Past-President of the American Institute of Mining Engineers, and Dr. S. W. Stratton, director of the Bureau of Standards at Washington, proved to be another interesting feature. A more complete account is given elsewhere in The Journal.

In connection with the meeting, the engineering alumni of nine colleges held reunions on Friday evening, following the practice of last year.

OPENING SESSION

On Tuesday evening, President James Hartness gave his address on the subject, The Human Element the Key to the Economic Problem. This address presented an analysis of the human characteristics that influence a man in his various efforts, and especially his accomplishments in industrial work, and showed the bearing which these same characteristics have on the industries themselves. He contended that large organizations are essential and that rightly conducted they are beneficial, since they seem to provide more nearly the conditions required for the happiness and success of the workman, when we come to analyze what the workman actually needs to inspire his best efforts.

Preceding the address there was a report given by the tellers of election of officers, showing the following votes cast: For President, John A. Brashear, 2034; for Vice-Presidents, Henry Hess, 2031; Geo. W. Dickie, 2033; James E. Sague, 2034; for Managers, Charles T. Main, 2035; Spencer Miller, 2036; Max Toltz, 2032; and, to fill the unexpired term of the late Alfred Noble, Morris L. Cooke, 1171, George J. Foran, 859; for Treasurer, Wm. H. Wiley, 2034.

An abstract of President Hartness' address follows, and the complete report will be published in the next volume of the Transactions.

ABSTRACT OF THE PRESIDENT'S ADDRESS

The world of mechanism has become so intricate and complex that it has gone beyond the capacity of any single individual. Each one must be content to comprehend only a small part, and only by selecting the character and limiting the amount of material that is taken into our individual minds can we hope to accomplish the best results. Under ordinary conditions the mind receives impressions from all directions, which, if unguided, may result in an undesirable trend in our personality and ability. On the other hand, by concentrating on those things which are of the greatest use to us, keeping in mind the laws of psychology, we may make a better use of our mental energy. The engineer should devote a part of his time to the care and study of his thinking machine instead of devoting it all to the machine created by that thinking machine. We should not overload our minds with data to the exclusion of thoughts of an initiative character.

Man is a creature of habit to an extent that renders this characteristic a dominant one, and the most efficient use of mind and body demands a scheme of life that permits each one to take advantage of this fact.

Specialization and repetition, by which habit is formed, are both essential to success. Carrying the principles of the individual into the realm of organized industry, it is a fact that large organizations are essential as affording an opportunity for the most complete sub-division of work and the greatest degree of specialization, both of which lead to the most effective employment of human energy. A most important element of the large manufacturing plant is its organization. Without this, the buildings and equipment are of little value. Antagonism to the large organizations should be directed against corrupt practices, and not against the organization itself, which involves the workers' interest. The greatest good to the greatest number requires that we take into consideration each human being, his desires and his needs in finding the work for which he is best endowed.

Granting that the large organization is essential in this age, not only in bringing out the best in the individual but in maintaining the supremacy of American industry against foreign competition, may it not be that we may approach the ideal which we may assume to be somewhat as follows for a large industrial plant:

It should have a capital equal to or as large as any competing organization. If possible it should have a small harmonious board of directors with an able leader. But if the directors merely represent the monied interests without special knowledge of the industry, then it would be sufficient if they were capable of appointing an able staff of officers, the chief executive of which should combine a knowledge of the technical and business side of the industry with the fullest possible conception of the human element. He should stand firmly for the cardinal principles of industrial economics as based on the human characteristics. Each officer should possess some special knowledge essential to the organization, so that the combined staff would have a general knowledge of all the various branches.

The chief executive should make it known that long continuity in service of each man in office will be given the first place in the scheme of management, and this should not only include the officers, but it should be the key to the management of the entire organization.

The period of years of service of each man in the organization in a given task or in a given office should compare favorably with competing organization.

It should be the aim of the executives to fill each position throughout the entire organization with someone who considers that position the best place in the world for him. Each officer and each workman should have a live interest in his part of the work. Each one should by specialization become the most efficient in his particular work. The interest of the officer or worker should be maintained by some fitting stimulus, and each one should be protected so far as possible from influences calculated to induce discontent.

Each man should be treated in a respectful manner. Needless direction or heartless correction by an overbearing executive should not be permitted. Criticism or reprimand should not be uttered in the presence of others, for the best control of the organization comes from contact with the better side of man, and that side is not reached by one who rides rough-shod over a man's self-respect.

Personal dignity and self-respect is an important characteristic in everyone. It is not the exclusive quality of those whose self-respect is very apparent, nor is it limited to those whose natural conduct and bearing indicate their high regard of the esteem of others. It is to be found in the entire human family, and he who fails to see it, even in an apparently careless person, is blind to a very important part of the human spectrum.

As these truths become known will it not be possible to formulate general rules of management of industrial organizations that will be of great value to both the investor and the promoter? With such rules the investor could see to what extent an organization conforms to success standards. There would be in addition to the regular treasurer's report a human report. The human report would begin with a description of the directors and go through the entire organization. This report would contain a statement regarding the elements of harmony of organization; of length of service of manager and workers; the frequency of change of methods or article manufactured; intelligence of executives in the management of men; the degree of contentment of each member; the extent to which each man in the organization approaches the best position for which he is endowed and how nearly he obtains the best remuneration for which he is qualified; the extent to which the management recognizes the inertia of habit of both mind and body; the degree in which the various men in the organization approximate the condition of highest efficiency; the extent to which the management goes in expression of appreciation; the degree of its knowledge of the most important characteristics of man as indicated by his inner motives and desires and the condition of his mind as he goes to his home at night. No mention is made here of the conditions of buildings from the point of sanitation and comfort, for such conditions are now closely scanned; but mention has been made of a few of those other conditions that must some day be measured just as we now measure power and other less vital things.

All of these elements should be carefully appraised and the average should be the rating of the company. The investor who considers this human rating with the treasurer's statement will seldom make a mistake in estimating the true worth of an industrial organization.

May we not hope that tabulations of these various elements taken from a variety of industries will lead to establishing a standard that will be a guide to both the manager and the investor?

Surely the investor should look with distrust upon a management that is always changing officers, changing men, changing models, changing methods without regard to the inertia of habit and the human element which is the life blood of every organization. He would also look with doubt on any scheme of management that allows the careless employment and discharge of men without due regard to the loss involved by such changes, for the perpetual changing of men is equivalent to the change of character of work in its handicap to industrial efficiency.

WEDNESDAY MORNING SESSION

The annual business meeting occupied the session of Wednesday morning, and the annual reports of the Council and Standing Committees were presented by the Secretary. The committee reports were printed in the December issue of The Journal and the Council report will appear in Volume 36 of Transactions.

In presenting the report of the Council the Secretary called attention to the varied work which the Society is successfully carrying on. Standardization work has been actively followed by the committees on flanges, pipe threads, boiler specifications; dimensions in screw threads; threads for fixtures and fittings; changes in the patent laws of the United States; specifications for fire hose and the tests for hose; power tests, a most voluminous report comprising standard methods for testing prime movers and all types of auxiliary apparatus; researches into the subject of standardization of safety valves; and standardization of commercial filters.

As a further development of the Society's work and a part of the work of the Committee on Meetings, subcommittees are at work in a great variety of branches of the engineering profession, such as the science of administration, cement, fire protection, air machinery, depreciation and obsolescence, hoisting and conveying, industrial building, iron and steel, machine shop practice, railroads, textiles, and a new committee on protection of industrial workers. Five of these committees have produced papers or reports for the Annual Meeting. It is the expectation that eventually all committees will not only make comprehensive reports on the progress of their branch of engineering, but fur-

nish one or more specific papers of major importance. It is thus intended that the Transactions shall contain each year an authoritative review of the state of the art.

Prof. F. R. Hutton presented a report of the Committee on Society History, describing what the history would aim to do, and stating that it had been found necessary to issue it by subscription. The manuscript has been prepared by the painstaking labor of Professor Hutton whose familiarity with every detail of the Society's activities from its organization has made it possible to introduce a great deal of matter of general interest beyond what is included in the formal records of the volumes of the Transactions. The text is enlivened by an account of many incidents relating especially to the early meetings of the Society by which the personal characteristics of the small group constituting the membership are vividly portrayed. Of perhaps still greater interest is the historical development of policies and precedents in the Society which have grown up with the years and which are somewhat apart from matters of definite history in the usual sense.

READING ROOM

THE VIEWS ON THIS PAGE SHOW THE THREE LARGE CONNECTING ROOMS AT THE HEADQUARTERS OF THE SOCIETY WHICH WHEN THROWN TOGETHER PROVIDE A SPACIOUS AND ATTRACTIVE GATHERING PLACE FOR MANY OF THE SOCIAL EVENTS OF THE ANNUAL MEETING. HERE THE PRESIDENT'S RECEPTION AND THE LADIES' RECEPTION WERE HELD

SECRETARY'S OFFICE

COUNCIL ROOM

I. E. Moultrop then reported for the Committee on Increase of Membership and outlined its work. During the fiscal year 1913-1914, 1195 applications have been received, making a gain of over 14 per cent more than were received during the previous year. During the four years since the establishment of the committee, 3418 applications have been received, a number almost equal to the total membership, 3899, of the Society previous to that time.

Mr. Moultrop laid stress on the importance of welcoming the large number of new members who are coming into the Society. At every convention there are new faces and it is difficult to remember names where members have been met only once or twice before, and he knew that every effort would be made to introduce such members and to give them a hearty welcome to the convention. To this end the plan had been adopted of giving to each new member a blue ribbon to wear in his lapel and all the older members had been requested to greet and introduce these new members.

The amendment to C-45 of the Constitution relating to the addition of a standing committee on Standard-

ization was then read by the chairman of the Committee on Constitution and By-Laws, Jesse M. Smith, and ordered by the meeting submitted for letter ballot.

The following resolution was then adopted:

Resolved: That the form of publication of The Journal and the continuance of the publication of the Transactions in its present form be made the subjects of a referendum mail vote to the membership of this Society and that the form of letter ballot be decided upon by the Council.

The remainder of the meeting was devoted to a discussion of the Boiler Code, reported elsewhere in this issue.

PROFESSIONAL SESSIONS

The professional sessions will be reported in detail in this and succeeding issues of The Journal, with a more complete printing of the papers and discussion in the annual volume of the Transactions. As in recent years, the Committee on Meetings has aimed to have sub-committees in charge of sessions or at least to submit papers in their respective fields, and this year there were papers offered by five committees, and an all-day session on Thursday on the Relation of the Engineer to Public Service in Municipalities, in charge of the Public Relations Committee of the Society, was made the feature of the convention. This meeting was opened by the Hon. John Purroy Mitchel, Mayor of the City of New York, and many prominent members of the Society were on the platform, among them Andrew Carnegie who at the close of Mayor Mitchel's address made a few humorous remarks, to which President-Elect Brashear, an intimate friend of Mr. Carnegie, retaliated in kind.

The sessions were well attended and the capacity which the Society has developed for conducting professional meetings was well illustrated on Thursday afternoon when there were two largely attended sessions in progress simultaneously, besides a session on the subject of Cement Manufacture with 40 or 50 present, and a meeting for the discussion of the Boiler Code with an attendance of 100.

The following is a list of the papers presented during the convention:

FLOOR SURFACES IN FIREPROOF BUILDINGS, Sanford E. Thompson.

REINFORCED-CONCRETE FACTORY BUILDINGS, F. W. Dean.

MEASURING EFFICIENCY, H. L. Gantt.

STANDARDIZATION IN THE FACTORY, C. B. Auel.

OPERATION OF GRINDING WHEELS IN MACHINE GRINDING, Geo. I. Alden.

FRICTION LOSSES IN THE UNIVERSAL JOINT, P. F. Walker and W. J. Malcolmson.

STEAM LOCOMOTIVES OF TODAY: Report of the Sub-Committee on Railroads.

THE FUTURE OF THE POLICE ARM FROM AN ENGINEERING STANDPOINT, Henry Bruère.

SOME FACTORS IN MUNICIPAL ENGINEERING, Morris L. Cooke.

THE NEW CHARTER FOR ST. LOUIS, Edward Flad.

THE ENGINEER AND PUBLICITY, C. E. Drayer.

SNOW REMOVAL: A Report of the Committee on Resolutions of the Snow Removal Conference held in Philadelphia, April 16 and 17, 1914.

THE DESIGN AND OPERATION OF THE CLEVELAND MUNICIPAL ELECTRIC LIGHT PLANT, Frederick W. Ballard.

THE HANDLING OF SEWAGE SLUDGE, George S. Webster.

TRAINING FOR THE MUNICIPAL SERVICE IN GERMANY, Clyde Lyndon King.

A STUDY OF CLEANING FILTER SANDS WITH NO OPPORTUNITY FOR BONUS PAYMENTS, Sanford E. Thompson.

FACTORS IN HARDENING TOOL STEEL, John A. Mathews and Howard J. Stagg, Jr.

STANDARDIZATION OF CHILLED IRON CRANE WHEELS, F. K. Vial.

THE MECHANICAL ELIMINATION OF SEAMS IN STEEL PRODUCTS, NOTABLY STEEL RAILS, R. W. Hunt.

TOPICAL DISCUSSION ON ALLOY STEELS.

A RATE-FLOW METER, H. C. Hayes.

LABORATORY FOR TESTING AND INVESTIGATING LIQUID FLOW METERS OF LARGE CAPACITY, W. S. Giele.

A NEW VOLUME REGULATOR FOR AIR COMPRESSORS, Ragnar Wikander.

PHYSICAL LAWS OF METHANE GAS, P. F. Walker.

THE CLINKERING OF COAL, Lionel S. Marks.

DAMAGES FOR LOSS OF WATER POWER, F. W. Dean.

EXCURSIONS

A number of interesting and instructive excursions were arranged by the committee in charge, John P. Neff, Chairman, and proved unusually successful.

A party of 20 made the trip to Ellis Island on Wednesday morning, under the guidance of H. R. Cobleigh, and were shown through all the departments of the immigrant station. The visitors were particularly interested in the tests which are applied to the immigrants to determine the desirability of admitting them, and also in the restaurant where the immigrants are fed at a cost of 24 cents a day. Leaflets placed in the hands of each visitor gave briefly the salient features of the building and the methods pursued in the work.

The Hill Building was visited by a party of 25 on Wednesday afternoon, C. W. Dibble acting as guide. This is the heaviest and most substantial building of its size in New York, not a single piece of wood entering into its construction. It is essentially a printer's building, and although only 12 stories in height is as tall as an ordinary 17-story building. The building is sealed, all air being filtered and washed before being forced to the different floors. The three intake fans handle 47,000 cu. ft. of air per minute, while the two exhaust fans on the roof handle 67,000 cu. ft. per minute. Drinking water is filtered, cooled in an ice plant, and supplied to bubblers on each floor. A pressure sprinkler system is used throughout, and in addition there are two automatic fire alarms on each floor connecting directly with a firehouse less than a block away. The office floor of the Hill Company is completely covered with interlocking rubber tiling, which almost eliminates all noise of walking, and in addition to this Noiseless typewriters are used. Machine dictation is used exclusively. All the furniture except the chairs is of steel, and the lighting is entirely indirect. The building has its own power plant, containing three 250-kw. Erie City engines of the Lentz type. The

boiler plant is of Heine boilers, equipped with Taylor stokers, and so arranged that there is no necessity for shoveling coal. This is delivered to the stokers by a bucket, working direct from the coal bunkers, and the ashes are removed by vacuum and carried up into an ash container where they are automatically sprinkled. They fall by gravity into ash carts driven under the ash storage. Buses provided by the company conveyed the party to and from the building.

A party of 38 visited the new long distance telephone office on Walker Street on Wednesday afternoon, conducted by Francis P. Davis. Upon arriving at the building the party was divided into groups of five, with three guides to each. This office was put into service during January 1914, and is the largest and most modern long distance exchange in the world. The switchboard consists of more than 200 operators' positions, occupying two entire floors in a large fireproof building, and handling approximately 13,000 outgoing and incoming calls per day. An interesting feature consists of a pneumatic tube system by means of which tickets containing information in regard to calls are carried from one part of the office to another. Much interest was taken by members of the excursion in the provision made by the company for the welfare of the operators.

Through the courtesy of Rear-Admiral N. R. Usher, Commandant, 90 members made an interesting trip to the Brooklyn Navy Yard under the guidance of W. P. Hayes and E. S. Cooley. The tug Powhattan had been placed at the party's disposal, and the visitors were conveyed from the foot of East 23rd Street to the Navy Yard, thus making a novel approach. They were shown through the machine shop, boiler shop, foundry and power house and noted the various points of interest. Three submarines were also seen in drydock and a comparison with the original Holland submarine, mounted in the yard, showed what strides have been made in developing this type of vessel. The dreadnought Wyoming, of 26,000 tons burden, was then inspected. This has 12-in. rifles, 50 ft. in length, and its engine rooms are equipped with turbines developing 33,000 h.p. showing great compactness of installation. The dreadnought Rivadiva, just completed by the Cramp Shipyards for the Argentine Republic, was viewed as it went into drydock. This vessel is armored with twelve 12-in. rifles as well as numerous smaller caliber guns, and is fitted with a torpedo net. It develops a horsepower of 39,500. The party returned to Manhattan on the same tug. The various points of interest at the Navy Yard were explained by Lieut.-Com. S. H. R. Doyle, supervising the construction of the new dreadnought Arizona, by Lieut. C. A. Blakeley, in charge of the machine shop, and by Lieut. C. W. Nimitz, the naval expert on Diesel engines. Lieut. H. G. Shonerd acted as the general guide.

On Thursday afternoon a party of 135 visited the studio of the Biograph Moving Picture Company on 175th Street. The party was divided into three groups and shown through the building by Mr. J. J. Kennedy and his assistants. The building is five stories in height, of reinforced concrete and fireproof construction. The laboratories for developing, reproducing, etc., are on the top floor, as is also the large daylight studio with its immense glass dome, for use in fair weather. A number of different scenes can be taken at one time in this room. The artificial light studio is located on the third floor and is arranged for four stage settings. At the time of the visit three of the stages were in operation, and the visitors saw several rehearsals and the final production. Each scene is rehearsed until it can be carried through in the definite length of time allowed for the act, and two reels are taken of the finished product, one of which is preserved and the other developed. The light effect is produced by the mercury vapor lights, with tubes approximately four feet in length and arranged in batteries of 24 to 30. The batteries are on racks which can be shifted around in different positions and adjusted to produce practically any light effect required. The studio is working 20 hours out of each 24, as the demand for reels is greater than the company can supply, even with its force of 300 or 400.

On Friday morning an instructive trip was made by about 60 members to the United Electric Light & Power Company's generating station at 201st Street, J. H. Lawrence acting as conductor. Buses furnished by the company conveyed the members to the power station, and two hours were spent in inspecting the various equipment. This power house represents the latest type of power station design in this vicinity and is unique in that the main units and auxiliaries are all turbine driven. The plant will have a capacity of 120,000 kw., three units of 15,000 kw. each being at present in operation. There are 32 boilers of 650 h.p. each, with provision for 40 more if necessary. All of the boilers are equipped with the Metropolitan cinder catcher, which has proved very successful in this work. Luncheon was served to the visitors in the plant by the company.

Small groups also visited the Bureau of Municipal Research on Wednesday afternoon and the McCall Corporation on Thursday morning, R. V. Wright acting as guide in the latter case. It was expected that the members would have the opportunity of inspecting the S. S. Lusitania, but this proved to be impossible.

WEDNESDAY AFTERNOON SESSION

SYNOPSIS OF PROCEEDINGS OF AFTERNOON SESSION OF DECEMBER 2, 1914, OF THE ANNUAL MEETING

FLOOR SURFACES IN FIREPROOF BUILDINGS

BY SANFORD E. THOMPSON, NEWTON HIGHLANDS, MASS.

Member of the Society

No one type of floor surface is adapted to all conditions, and having selected the proper type, the choosing of the materials and the manner of the construction govern to a large extent the durability of the surface.

It is the purpose of the paper to discuss briefly the different kinds of floor surfaces; indicate the types of construction which may be selected under different conditions; give approximate costs of various floor surfaces; describe tests and investigations of granolithic construction made in connection with the buildings for New Technology (Mass. Inst. Tech., Boston, Mass.); and present recommendations for granolithic construction.

Summarizing the discussion on the characteristics of floors:

Granolithic Trowelled. As ordinarily laid in buildings, granolithic or concrete surfaces are subject to dusting and under heavy traffic, such as trucking, are liable to serious wear. On the other hand, experience with first-class construction and tests of actual floors show that it is possible, by proper selection of the aggregates and expert workmanship, to reduce the dusting to an insignificant amount and to produce a surface hard enough to stand even severe wear. The chief objection to concrete or granolithic surfaces for offices, drafting rooms, classrooms, laboratories, etc., is that it is hard on the feet for men standing all day, tends to break tools dropped upon it, and is not adapted for attaching seats or other furniture. In certain colleges, however, concrete floors are used widely and are highly recommended. In one instance the men complained of coldness and hardness where the floor was laid directly on the ground, whereas, where there was a warm basement underneath no objection was raised. Cost, 5 cents to 7 cents per sq. ft.

Granolithic with Ground Surface. Experimental surfaces, together with laboratory tests made as a check, show that a pleasing surface, approaching terrazzo in appearance and fully as durable under foot traffic, can be obtained by placing granolithic with scarcely any troweling, and then grinding the surface just enough to expose the grains of sand and stone. It is suggested that this grinding might remove the objection of dust previously referred to. The extra cost is estimated not to exceed 3 cents per sq. ft.

Linoleum. The hardness and noise characteristic of granolithic finish are overcome by covering the surface with Battleship linoleum. The linoleum should be stuck firmly to the granolithic surface and preferably a cove base should be run around the room and sills provided at entrances so that the surface of the granolithic will be flush. In this way the edges are prevented from fraying. The life of first-class quality Battleship linoleum, if edges are not frayed, is probably from 15 to 30 years, depending upon the amount of travel. The cost, allowing for the better finish required on the concrete, is substantially the same as for a single floor of birch or maple. Cost, 18 cents per sq. ft., including 3 cents per sq. ft. for ¾ in. layer of mortar.

Hardwood Floors. Floors of maple, birch, beech, oak or long-leafed Southern pine, are used most largely for offices, classrooms, or lecture rooms, and in many of the older colleges for laboratories and halls. A wood surface, however, is not usually considered entirely satisfactory either in general appearance or in wearing qualities. There are various methods of laying hardwood floors. For classrooms a single thickness of maple or birch nailed to sleepers with cinder concrete between should be satisfactory. Another type of construction is to use patented metal screeds imbedded in the base concrete, and nail the floor boards to splines in the screeds. For rooms subjected to heavy traffic, 2-in. or 2½-in. plank may be placed underneath the hardwood floor. Cost 18 cents to 25 cents per sq. ft. based on a price of $45 per 1000 board measure.

Terrazzo. This is made by spreading upon the base concrete a mixture of neat cement and marble chips and grinding the surface to a depth sufficient to cut into the stones and expose them on their largest diameters. The joints between the particles, being of neat cement, are hard and even more durable than the pieces of the marble themselves.

Terrazzo is largely used, especially in the newer office buildings and in institutions, for corridors and halls. It also is satisfactory for lavatories, although more expensive than granolithic. It appears from the author's investigations that for both of these uses concrete with a ground surface can be substituted at less cost and with satisfactory results. Cost, 19 cents to 24 cents per sq. ft.

Magnesium Composition. Suitable for offices, class,

Abstract of paper presented at Annual Meeting, December 1914. Complete paper may be obtained without discussion, price 5 cents to members; 10 cents to non-members.

lecture and drafting rooms, and laboratories. If carefully laid it wears satisfactorily. Any imperfections are apt to show within the first year. It is more resilient than granolithic, less noisy, and furniture can be screwed directly to it. Colleges have used it extensively, especially for certain laboratories, and Cooper Union in New York City have many such floors proving satisfactory. Cost, 20 to 24 cents per sq. ft.

Essentials of Granolithic Construction. Aggregates should contain no dust but should consist chiefly of particles ranging from $\frac{1}{16}$ in. to $\frac{1}{2}$ in. in size.

Proportions with first-class materials should be one part cement to two parts aggregate.

This mixture should be of such consistency that it will not flow but will hold its shape in a pile without settling.

A perfect bond must be made with the base concrete either by laying the granolithic before the concrete has set, or else roughening surface and providing a bond of neat cement paste.

Laying must be done at moderate temperatures, avoiding temperatures below 50 deg. fahr.

Troweling should be thorough but no excess water should be brought to the surface. A hard, dense surface rather than a smooth, glossy surface should be the aim.

The surface should be kept wet for at least ten days to two weeks after laying.

In General. The paper contains also a table of approximate costs of the different floor surfaces, which are given more in detail than mentioned in the above summary. There are also a set of specifications for laying granolithic finish on set concrete and specifications for grinding granolithic surfaces.

DISCUSSION

In presenting the paper the author said that good granolithic floors were being built which will stand very severe traffic and that will dust only to a very small degree. The five principal requirements are: Materials, proportions, bonding, methods of laying, and treatment of surface, if any. Use coarse material with the cement, avoiding fine sand or stone with fine particles because this rises to the surface in trowelling. Use a comparatively dry mix that will have to be put on with the aid of tampers. There are certain compounds on the market that will prevent dusting, but if the right materials and workmanship are employed, so little dusting will occur as to do no harm for ordinary purposes.

For durability it is best to lay the floor surface along with the base concrete. This is often almost impracticable and tests have proven that a good bond can be obtained on old concrete with the proper treatment. Special attention is called to the specifications given at the close of the paper to laying granolithic in cold weather.

ROSS F. TUCKER. So much difficulty exists in securing a good wearing surface for granolithic that hardwood is preferred for all purposes, particularly where operatives have to be on their feet.

L. C. WASON. The cost of granolithic quoted by the author is too high by 10 cents per sq. ft. There is also a difference of $3\frac{3}{4}$ cents per sq. ft. between hardwood floors 2 in. face by $1\frac{1}{8}$ in. thick as against $3\frac{1}{2}$ in. face by $\frac{7}{8}$ in. thick. Magnesium composition is also laid at a third less than quoted.

It has been found that factory operatives claim that lameness and fatigue are caused by granolithic floors being better conductors of heat and cold. This has been overcome where floors are cold by wearing heavy shoes.

Nalecod, another material composed of asbestos, portland cement and sand, is giving better results than screed for wood floors.

For a granolithic floor no particles should be used smaller than those passing a No. 30 sieve, and hard rock which will withstand abrasion should be used, without any sand, the proportion being one to two. It is also pointed out in bonding to old surfaces that a thin top, i. e., $\frac{3}{4}$ in. or 1 in., is more likely to come loose than a thicker one.

Commenting on Appendix No. 1, a multiple pick is cheaper and requires a less experienced workman than a bush hammer.

Dilute muriatic acid is unsafe unless the concrete is dense, otherwise it is likely to soften it.

The mixture should not be limited to granite, as traps and gravel give good results. A stiff mortar gives best results, although a different consistency should be used, depending on whether the base is fully set.

Much better results can be obtained by using a wood float than a steel trowel. Specification should read, Float granolithic surface as soon as it begins to stiffen. Commenting on Appendix No. 2, better results can be obtained with wet grinding than with dry.

G. S. WALKER. There is almost certain to be trouble with granolithic if the base is allowed to set and an attempt afterward made to bond the surface to it. This is due to the shrinkage rate being different. They should always be laid together.

WALTER S. TIMMIS. There is a very serious defect in wood floors in fireproof buildings, that of springiness. This was more apparent in the earlier buildings where floors were laid directly on the arches, but even in recent buildings it occurs, owing to care not being exercised in bringing the cinder fill to the top of the screed. Dry rotting of screed also often takes place, especially when the floor is laid before the cement is dry. On granolithic floors, the difficulty in getting a smooth surface and no dusting is due to the trowelling not being done at the psychological moment.

GEORGE P. HEMSTREET in a written discussion, called attention to another form of asphalt floor for fireproof buildings, streets, piers, warehouses, etc., used for many years, viz., asphalt blocks composed of hard crushed stone and about 7 per cent asphaltic cement formed under hydraulic pressure of various sizes and forms. These are laid in cement mortar with joints grouted. The surface is smooth, resilient, non-slipping, dustless, sanitary and not easily marred. The cost is $1.50 to $2.50 per square yard.

THE AUTHOR, in closing the discussion, agreed with Mr. Wason's description. Regarding bonding new to old, the

best answer is the fact that it has been done with good results due to the neat cement applied to the roughened surface which seems to overcome the theoretical difference in expansion and contraction.

REINFORCED CONCRETE FACTORY BUILDINGS

BY F. W. DEAN, BOSTON, MASS.

Member of the Society

The reinforced-concrete factory building is in considerable favor at present and is likely to be increasingly so. It is fireproof and gives the maximum resistance to fire. Other merits are the possibility of greater window area over the regular mill construction, the light color of the ceilings and adaptability for heavy floor loads without requiring narrow bays.

There are two general types of floor construction, one with beams, the other with smooth ceilings known as the mushroom construction. For factories, especially when lineshafts with large pulleys are used, the beamed construction is preferred, while for storehouses and machine shops with light motor-driven machines the smooth ceiling is better. The strains in the mushroom system are more uncertain but, in practice, no inconvenience or risk arises.

In the beam system the building as a whole is encased in forms, while under the Ransome or "unit" system the columns and beams are cast separately on account of which it is claimed, probably with truth, that the latter method is cheaper.

It is claimed that owing to the rigidity machines can run faster with less vibration than in a mill construction building. This is probably true, but speed is dependent on other things than the rigidity of the building, such as the limitation of the machines themselves, personal skill and accompanying processes. The larger columns necessary are a disadvantage and in textile mills are intolerable. Sometimes steel columns encased in cement are used.

Concrete floors always are a source of trouble on account of wearing unevenly, especially under heavy trucking. Coarse crushed granite in a rather dry cement has been unsuccessfully tried, and the various compositions for preventing wear are so expensive as to necessitate their being used sparingly.

A disadvantage in concrete buildings not occurring in mill construction is the necessity of working out in advance many things in connection with placing machinery, wires, pipes, etc., as well as the difficulty of correction afterward. On the other hand, if planned for, many sockets, inserts and angles for hangers can be placed during construction.

The dusting of floors is a difficulty especially where the dust affects the product. A wood floor is therefore often required and this is preferred as well by operators because the concrete is cold. The best way to lay a wood floor is to place thick planks kyanized or otherwise treated to prevent rot, with the top floor nailed to the planks. This produces a floor of the necessary stability.

The exterior can be treated to obliterate the form marks in different ways by tooling with a pneumatic tool, or washing with a marble, cement or other wash. There is no limit to the ornamentation and beauty that can be given.

Sprinklers are needed as the contents are inflammable. In one case the furniture made a fire that cracked the cement off the reinforcement. The Salem fire showed the importance of abandoning overhang roofs, wood window frames and sashes. In this fire, however, the brickwork offered effective resistance, and with the building walls extended above the roof a mill construction building with metal frames and sash with wired glass will usually withstand an external fire.

The difficulty of demolishing a building tied together in all directions with steel rods encased in material that has become as hard as rock is interesting to consider. As to cost, while it has often been stated that reinforced concrete can be built as cheaply as mill construction, the writer's experience is that the former costs fully 20 per cent more.

It is common practice to fill in the panels with brick, because it is cheaper and looks better. The latter is a matter of taste, the former is questionable, and in Germany, where reinforced concrete has been carefully investigated, such construction has not been found advisable.

Where fireproof construction is paramount and where heavy floor loads are to be sustained, reinforced concrete buildings are desirable; but if these requirements do not exist and the location is isolated, it is hard to justify the additional expenditure.

In presenting the paper the author said that in the Salem fire the behavior of the Naumkeag mill buildings had opened the eyes of engineers because these buildings took fire in consequence of their overhanging wooden roofs and wood window frames, but more especially because one old brick warehouse where the roof was completely protected by a brick parapet stood the fire as well as certain concrete warehouses.

DISCUSSION

GEO. C. STONE contributed a written discussion in which he said the author had a seeming prejudice against the use of reinforced concrete for factory buildings and insisted that with a fair comparison of advantages and especially of wide bay construction, which is readily obtained in concrete buildings but which is quite an item of expense in mill construction, in that it requires steel beams, the cost of the two types is nearly equal or even in favor of reinforced

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Abstract of paper presented at Annual Meeting, December 1914. Complete paper may be obtained without discussion, price 5 cents to members; 10 cents to non-members.

concrete. Besides, reinforced-concrete construction is fireproof. He amplified the good features of reinforced concrete (over mill construction) mentioned by the author, in the following respects:

The floors of concrete are in themselves sufficiently waterproof to prevent water passing through into the story below. Larger window area can be obtained even up to 85 per cent of the gross wall area.

An initial expenditure of $^2/_3$ of one cent per sq. ft. of ceiling area will provide for a liberal placing of inserts which will make the building perfectly elastic for the entire rearrangement of any ordinary kind of overhead machinery.

Additional floor surfaces are mentioned, i.e., plain troweled cement, wood top floor on screeds in cinder cement, wood block on end, terrazzo, linoleum and tile, each with its advantages peculiar to itself.

Regarding architectural effects, it is suggested that more attention could be given to the jointing between the separate pourings, treating these from a design point of view and getting away from the habit of considering the building as a monolith instead of a series of gigantic blocks of artificial stone laid one upon the other and doweled or otherwise fastened together, as it really is. There is no limit to the ornamentation and beauty that can be given, this being dependent only on what is justified for that purpose.

Regarding the fireproof features, attention is called to one of the Naumkeag storehouses in Salem which is of reinforced concrete construction with wired glass windows and was not mentioned by the author. This came through the fire with its glass windows buckled but with its frame uninjured and its inflammable contents unharmed.

J. P. H. Perry presented a written discussion in which he said he thought the author to be unfair to the recognized merits of properly designed and executed reinforced concrete construction for industrial purposes. In view of the tremendous fire loss in this country, it seems unwarranted to recommend non-fireproof or slow-burning construction whenever the owner can possibly afford a fireproof building, especially in view of the difficulty of securing high-class timber and the difficulties with dry-rot.

A number of plants, notably printing houses, have obtained greater efficiency from reinforced-concrete buildings because of, first, their less vibration, and second, the fact that shafting remains permanently true. Upkeep has also been less.

Steel columns have been used in only a small percentage of buildings. The octo-spiral columns of the Hoadley type avoid the waste space occupied by square columns and are better in appearance.

It is too severe to claim that concrete floors "cannot be uniformly dense or hard and that they wear unevenly." The many millions of feet of such floors giving reasonable satisfaction is an answer to this. Some bad floor work is, of course, done and good floors are damaged by severe trucking. Floor hardening materials help, but wax driven into the floors does very little to improve the quality of first-class jobs.

In practice, the difficulty of attaching shafting is very small. At a small added expense, extra sockets of many different forms, now well commercialized, can be frequently located to provide fastenings when changes are required. An electrically driven portable drill has proved efficacious in tapping holes in the concrete in any part at small expense.

Contrary to the author's statement, the majority of chocolate factories in the country are using reinforced concrete with complete satisfaction.

Rarely are board marks removed, but it can be done without a considerable expense by tooling, or the exterior can be stuccoed or veneered with brick or tile. The general appearance depends mainly on the proportions of the structure and the simplicity of the ornamentation plus some wash or paint treatment to bring the exterior to a uniform color. A critic's opinion will be favorable if he will consider the concrete as concrete, not as brick or other material.

Brick curtain walls are often introduced to get what some consider a more pleasing effect. Sand blasting has not usually proven satisfactory because it tends to pick out the soft spots. A cold chisel worked by hand is better.

The author overlooks the four-story reinforced concrete warehouse of the Naumkeag Mills in Salem which withstood the fire without an interior sprinkler going off. The storehouse he refers to was formerly a gasometer without widows and with a newly laid asbestos roof, but with a wood skylight at the peak. The warehouse was undamaged, due probably to a recognized phenomenon, viz., the collection of cold air in spots. All the other mill constructed buildings of the Naumkeag Mills which were recognized by the Mutual Insurance Companies as one of their best risks were destroyed, many brick walls collapsing.

There have been many instances of a fire in a mill construction building where the sprinkler equipment has been cut in two by the early blaze and the rest of the plant entirely destroyed as a result.

Removing concrete buildings has, contrary to the author, been worked out economically and efficiently.

Many competitions in the metropolitan territory have shown an increase over mill construction of 8 per cent to 15 per cent, but if the same floor loads and column spacing are allowed, the cost would be about equal.

The question of adhesion of concrete to bars has been thoroughly demonstrated. With deformed bars at least the stresses assumed in design will be distributed and obtained in actual work. A laboratory test proved that if a commercial smooth bar was milled smooth the bond was materially reduced.

Walter F. Ballinger took exception to using the circular storehouse of the Naumkeag Mills as a sample of the fire-resisting qualities of mill construction. Regarding comparative costs, there have been instances where the difference in proposals has been as low as six cents per sq. ft. between an entire reinforced-concrete building and one of the slow burning or mill construction; in certain circumstances where supply of material is at hand and where railroad sidings exist reinforced concrete is less expensive. In the majority of cases, insurance and upkeep considered, reinforced concrete is usually more economical.

Reinforced concrete permits a small number of posts and greater spans and with the use of the spinal type of column, it need be no larger than yellow pine. It is practicable to build a span as long as 60 ft. This has been done at an actual saving over steel fire-proofed, and in one case was even cheaper than having the steel structure unprotected.

It is known that machinery will vibrate less in a reinforced-concrete building, and this has actually resulted in saving of electric current due to the machinery running more true.

Walter S. Timmis: Further objections to mill construction are, the difficulty of getting timbers for long spans properly seasoned, the time it takes to get timbers, and the shrinkage of beams away from the girders and the large amount of vibration. Except in buildings over eight stories, sizes of columns need be no larger than required by cities of the first class for steel columns fireproofed. The machinery layout and provision for changes merely resolves itself to putting into the concrete sufficient inexpensive inserts. Lay the plant out first and build the building around it. Most everyone believes in sprinklers in any type of construction.

The Author said in closing that one object in writing the paper was to create discussion and that he was appreciative of the contributions which so well accomplished this.

MEASURING EFFICIENCY

By H. L. Gantt, New York City

Member of the Society

The author contends that the attempt of the accountant to furnish the financier with easily obtainable measures of efficiency has not only been a failure, but that the attempt to use as measures of efficiency the criteria which he has provided, is one of the most serious causes of inefficiency with which the practical manager has to contend.

Fortunately for industry at large, the first fallacy, namely that it is necessary to have low wages in order to get low costs, is rapidly falling into disrepute; but the second, namely, that the ratio of non-productive to productive labor is a measure of efficiency, is still strongly and almost universally held by accountants and financiers. This fallacy, on account of its widespread acceptance, is responsible for more inefficiency than almost any other cause.

Inasmuch as the object of increasing the efficiency of an industrial operation is to reduce the cost of that operation, the only real measure of the efficiency with which the operation has been performed is found *in the effect on its cost.*

The only reliable indication, then, of the efficiency of a plant is furnished by the detail shop cost of the operations performed.

Before any great progress in the solution of our industrial problems can be made, the two fallacies referred to must be abandoned, for they not only directly hamper the operating executive in his efforts to promote efficiency, but impose upon him conditions that make it almost impossible for him to secure the proper coöperation of his employees, and are thus indirectly the cause of much of our industrial unrest. In reference to these two fallacies the author says:

With the growth of competition within the last 20 years the necessity for some knowledge of costs became evident, and the manufacturer turned to the accountant for a system of finding costs.

The present system of railroad accounting had been developed, and certain ratios accepted as measures of efficiency of operation; notably among them the ratio of operating expense to total income.

Being accustomed to having the managerial efficiency of railroads expressed by a simple ratio, the financier demanded a similar simple measure of the efficiency for an industrial plant. The cost accountant promptly gave him what he called the ratio of "non-productive" to "productive" labor, which he said should be low for good management. By "non-productive" labor he meant salaries of all kinds, and all other labor that could not be charged directly to an order, including miscellaneous labor such as watchmen, sweepers, truckmen, etc. By "productive" labor was meant simply that labor which could be charged directly to an order.

While the ratio of operating expense to total income may be a fair measure of efficiency in a transportation company, the ratio of "non-productive" to "productive" labor is not only not a fair measure of the efficiency of operation in a manufacturing plant, but is often exactly the reverse.

To my mind the widespread use of this ratio as a measure of efficiency, has been more effective in producing inefficiency than any other single factor, except the oft-repeated statement that you must have low wages if you would have low costs. Until these two fallacies are absolutely discredited, we cannot expect a solution of our most serious problems.

Of these two fallacies, the second, namely, that you cannot have high wages and low costs, seems to be yielding gradually to the overwhelming mass of evidence against it. So many cases are now on record where the industrial engineer has increased output, raised wages, and at the same time lowered costs, that only those who are too conservative to investigate are still holding on to the old theory. Better still, many employers have shown the courage of their convictions by adopting a scheme of management for the increase of output and the reduction of costs, which they are perfectly well aware will make a decided increase in wages. With evidence of this kind at hand, it is safe to say that this fallacy will before long be entirely discredited. On the other hand it must be fully understood that something more than a simple increase in wages is necessary to increase output, and if nothing is done but to increase wages we are sure to get higher costs.

The other fallacy, that the ratio of "non-productive" to "productive" labor is a gage of efficiency, is so firmly rooted, however, that it is hardly to be expected that it will yield in the near future.

In speaking of cost systems the author states that the essential elements of a reliable system are a knowledge each day of

a what was done the day before
b who did it, and
c what was paid for it

It is comparatively easy to get a set of returns purporting to give this information, but the real difficulty comes in knowing whether these returns are correct or

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not. The only sure way of judging of the correctness of these returns is to know beforehand

a what should be done the next day
b who should do it, and
c what should be paid for it

If work can be planned on these lines the basis is formed for a real system of management. In fact, he says:

Even in the most poorly run business, some attempt, either consciously or unconsciously, is made to control work on these lines. Moreover, we generally find that the more nearly the above ideal is approached, the most successful the plant is, and all will admit the desirability of such a system if it can be established without excessive clerical work.

When it is realized that the installation of such a system seldom results in an increase of output of less than 25 per cent, and often as much as 100 per cent, it is easy to see that the additional clerical work cuts but little figure. As a matter of fact *the clerical work needed to operate the best systems of this type is decidedly less than that needed to operate any of the standard cost systems put in by chartered accountants.*

It must be borne in mind, however, that during the process of installing the new system and training the employees to operate under it, the old system must be continued; and not until each function performed by the old has been taken over by the new can we drop the old entirely.

During the process of installation, therefore, we must to a large extent operate two systems. This necessarily runs up the ratio of "non-productive" to "productive" expenses, and the accountant lifts up his hands in horror at the expense the new system is running them into. If at the same time the new system is successful in reducing the "productive" labor, the ratio is still higher, and the "showing" is still worse, even though the total cost is less. I therefore repeat that the first step to be taken before introducing a modern system of management is to eliminate the ratio of "non-productive" to "productive" labor as a measure of efficiency.

The elimination of this ratio as a measure, and the establishment of the fact that total cost is the only reliable guide, will do much to pave the way for an improved system of management. How is this to be accomplished?

The first step is to revise our ideas as to the functions of a cost system. In the past the principal function of a cost system, besides indicating a limiting selling price, has been to enable those in financial control to criticize those operating the factory. These criticisms are usually from one to three months late, and are so general in their character as to afford, as a rule, no guide whatever by which the superintendent can be governed. Such a system is too often most highly prized for its worst defect, namely, that it enables those in financial authority to criticize without taking any responsibility whatever for showing how to do better.

If, instead of making the function just described the prime one, we raise to equality with it, a function which requires the system to furnish promptly, day by day if necessary, exact information of what has been done and what the expenditure has been, we shall find that its most valuable function becomes, not finding costs, but furnishing the superintendent with information which helps him to reduce costs.

In other words, before we can expect to get any great benefits from the newer managerial ideas, we must readjust our ideas of the functions of the cost accountant, *who must become the servant of the operating executive as well as of the financial executive.*

As long as the cost accountant is simply a critic, he may be called "non-productive," but when he furnishes the superintendent with prompt information which enables him to reduce costs he becomes "productive." Prompt detail information of what is being done each day, furnished in such manner as to be readily compared with what has been done, and what can be done, is the best method of measuring efficiency.

DISCUSSION

HARRY E. HARRIS contended that the annual monetary return for the amount invested is what interests those responsible for any undertaking. This cannot be measured by any arbitrary rule of accounting, nor by a comparison of the earnings of the wage earner. Neither can it be judged by individual costs of separate operations without consideration of overhead factors, since it is possible to show by cost records a very high increase of efficiency and still operate under an increasing loss. Efficiency, taken in the sense of manufacturing at a low direct labor cost, is not always synonymous with economy, and therefore is not always expedient.

Rather than depend upon day-to-day costs, which, while valuable to a certain extent, are expensive to maintain, the writer preferred that efficiency should be measured periodically, by taking the total productive costs, *i. e.*, direct and indirect labor, plus salary expense, material, a portion of the cost of new equipment, etc., together with the total sales value of the articles produced during some period, and comparing their ratio with similar ratios taken at previous periods.

FRED J. MILLER said that the percentage of operating expense is of no importance by itself; a low percentage may mean a high total cost of product, or a high percentage a low cost of product. In a factory where the work is done mostly by hand, with low cost fixtures or tools, labor costs will be high, and operating expense or overhead charges low. Suppose, however, that automatic machines are devised for doing this work, and that almost no human agency is required for their operation. Under such conditions the percentage of operating expense might rise from, say, 20 to 1000 per cent, if based upon labor cost, yet under the second condition the total cost presumably would be lower. It cannot be too often insisted upon that the term "non-productive labor" is a misnomer; that there is no such thing as non-productive labor in a well-organized and well-managed industrial establishment. The work of clerks, draftsmen, pattern makers, tool makers, etc., is usually productive labor in the highest sense.

H. K. HATHAWAY said in elaboration of certain details referred to by Mr. Gantt that under scientific management, not only is the ratio between direct and indirect labor increased as a result of lowering the amount of direct labor through the elimination of wasted effort, but by transferring to others many of the things which the workman formerly

did himself, as, for example, the grinding of tools, fixing belts, planning the work, etc. This work is just as productive as if done by each machinist himself, although it is difficult to charge it directly to the various jobs to which it applies. Those who attach such great importance to the ratio of indirect to direct expense should consider that the more inefficiently those whom they class as producers do their work, the lower will be their ratio. The only satisfactory means for measuring efficiency is a comparison of work done with a task set, based on standardized conditions and accurate time study.

HENRY H. SUPLEE thought that in determining efficiency it was frequently done from the wrong end, that is, after operations were conducted, instead of with some reasonable degree of truth beforehand. He commended the principle involved in the simple methods of the man who manufactured clothing in New York. He made what he called "pants," and his method of reasoning was as follows: "I can sell these for $2.50 a pair. If I cannot sell them for that, I cannot sell them at all. I must make 50 cents profit on each garment, or I do not want to make them at all." He took out his profit first. That left $2 a pair for manufacture. Then he figured how many pairs an operator could make in a day, and how much wages he would have to pay the operator at the union rate. He figured his overhead charges, rent, clerk hire, etc., and after deducting all his expenses of this character, determined how much he had left to buy the materials, and the quality of the materials he purchased was covered by the amount at his disposal.

W. A. POLAKOV said that the quintessence of the shortest paper presented at that session, but on the biggest question, is the statement that the most valuable function of the management is not finding costs, but furnishing the superintendent with information which helps him to reduce costs. Information furnished by accountants is like that which tells us why a patient has died. What is needed is a diagnosis from which the management can learn before everything is over, what, when and how the work shall be done, and therefore how much it will cost.

It had been the good fortune of the speaker to work for and with the author, and as he was now applying the principles of Mr. Gantt to his own business of managing central stations, he had invariably found that an unprecedented increase of efficiency and reduction of costs is possible, if the operating force is supplemented by a body of "non-producers" constituting a planning department, whose office is to teach the producers what, when and how to do.

STANDARDIZATION IN THE FACTORY

BY CARL BENNETT AUEL, EAST PITTSBURG, PA.

Member of the Society

A brief outline is given in this paper of the ways and means employed by a large electrical establishment in their work of standardization.

Drawings: It was formerly the custom to make all drawings as complete and self-contained as possible. Opposite each item a note was placed specifying the material required to manufacture it. When drawings for new apparatus were made and any of the old parts could be used, these parts were shown again on the new drawings in complete detail, so that the workmen would not have to refer to any other drawing. This method was found to involve more and more a duplication of drafting and clerical work and the scheme of making elemental drawings with one piece on a drawing was next considered; but, while this insured accuracy in duplication, it had the disadvantage of too many drawings to handle. A compromise arrangement was therefore adopted, consisting of a natural grouping of pieces or parts on a single drawing. Each piece is assigned an item number and a list of the material involved is located conveniently on the drawing arranged numerically according to item numbers as shown in Fig. 1.

Fig. 2 shows a standard drawing of a line of wing nuts, arranged, however, in such manner that the various items may be cut into cards and issued to workmen who can attach them to the belt shifters of their machines when working.

Manufacturing Information: All apparatus and parts are built to so-called manufacturing information, which consists of a specification setting forth the drawings to be worked to, with a list of the various kinds and amounts of material required. Copies of such portions of these specifications and drawings as pertain are issued to all departments having work to do in connection with an order, and these specifications are closed when the order is completed.

Specifications and Shop Processes: When either the quality or the importance of the items warrant, specifications are carefully prepared for the purchasing and the inspection departments who use them in the purchase and the subsequent inspection of such materials. Another equally important line of work consists in the development of manufacturing processes and formulæ which, when standardized, are recorded in permanent form and issued to the various manufacturing departments involved. In this way uniformity in product is assured, there is no needless repetition of lessons or experiences previously learned, and the company is made independent of any individual's knowledge.

In the paper is reproduced a set of specifications for cold-drawn steel, the general arrangement of which is in accordance with the standards of the American Society for Testing Materials. An example is also shown of process specifications.

Visible Production Charts: In Fig. 3 is shown a form of production chart, or load diagram, used quite generally throughout the works. Curve *a* is the daily total of unfilled orders, machines or pieces obtained by adding to the total on hand, the number received each day and subtracting the number shipped. Curve *b* shows the maximum possible out-

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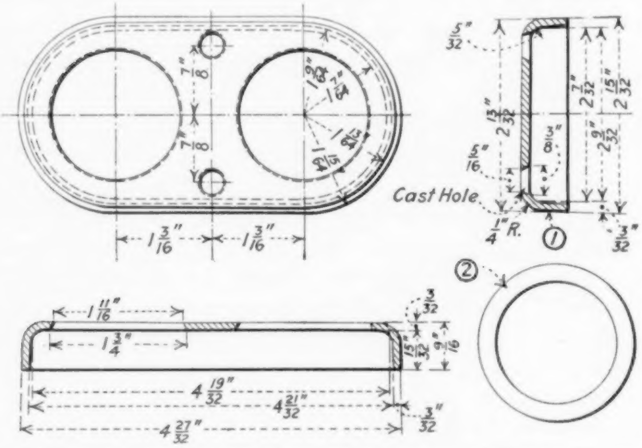
put of which the department is capable in a month. Curve c is the desired output for the same period. While these two latter are both straight lines, their shape could of course, be altered, though with a loss in simplicity. Curve d indicates the actual output and a comparison between it and curve c tells whether the department is working up to its schedule or falling behind. Curve e is that of actual daily deliveries.



Drawing No. 181577	BILL OF MATERIAL		Sub. No. 1		
Item	Description and Material	Pat No.	Req.	Dwg. No.	Tool No.
1	Flange C. I. S-No. 99665	U-8266	1		
2	Felt Washer S-No. 42053		2		

FIG. 1 MERCURY RECTIFIER OUTFIT. DOUBLE FLANGE FOR TRANSFORMER PORCELAIN BUSHING

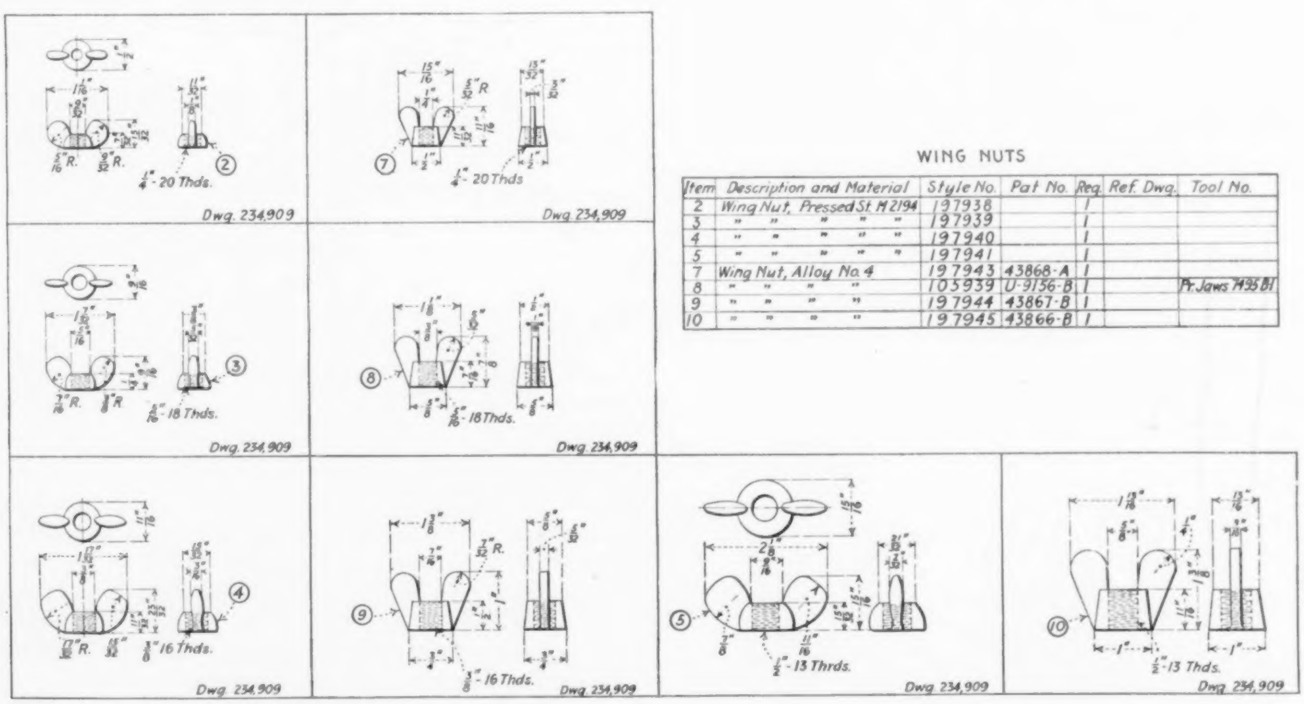
Standardization: Owing to the obvious need for having certain standard sizes and kinds of materials, the first steps in standardization naturally fell to the drafting department. Later a standards division of the engineering departments and a Standards Committee were created, whose functions are the standardization of existing materials and parts. The work of the Standards Committee has been varied in the extreme, such matters having been successfully handled as punched circular washers, thumb and wing nuts, oil-hole covers and hinges, furniture, anchor holes in bearings, wood handles, sizes of tap drills, stresses in eye-bolts, thickness of babbitt in bearings, liners, trucks, etc.

Cutting tools have been standardized as well as die and jig parts, die shoes, punches and punch holders, punch and stripper plates, jig boxes and bushings, drill press shanks, etc. Endeavor has been made to place on working drawings the allowable variations from drawing dimensions for standard parts.

The method which has been adopted consists in placing the nominal dimensions first, followed by the limiting dimensions in brackets: thus $4\frac{1}{4}'' \left\{ \begin{matrix} 4.251'' \\ 4.248'' \end{matrix} \right\}$. There has, however, been a certain preference expressed for a slightly different method, namely

$$4\frac{1}{4}'' \left\{ \begin{matrix} '' + 0.001 \\ '' - 0.002 \end{matrix} \right\},$$

but the objection to this method is that whoever uses these dimensions must add or subtract the allowance each time same are used.



WING NUTS

Item	Description and Material	Style No.	Pat No.	Req.	Ref. Dwg.	Tool No.
2	Wing Nut, Pressed St. M 2194	197938		1		
3	" " " " "	197939		1		
4	" " " " "	197940		1		
5	" " " " "	197941		1		
7	Wing Nut, Alloy No. 4	197943	43868-A	1		
8	" " " "	103939	U-9156-B	1		Pr. Jaws 7495 BH
9	" " " "	197944	43867-B	1		
10	" " " "	197945	43866-B	1		

FIG. 2 SECTION OF STANDARD DRAWING OF A LINE OF WING NUTS

Allowances for Expense Materials: The monthly

consumption of various expense materials, such as oils, greases, waste, incandescent lamps, janitor's supplies, etc., has been estimated for the individual manufacturing departments, based on normal production. From these investigations, allowances have been set on each item and a department is permitted to draw from the storehouse on requisitions up to its allow-

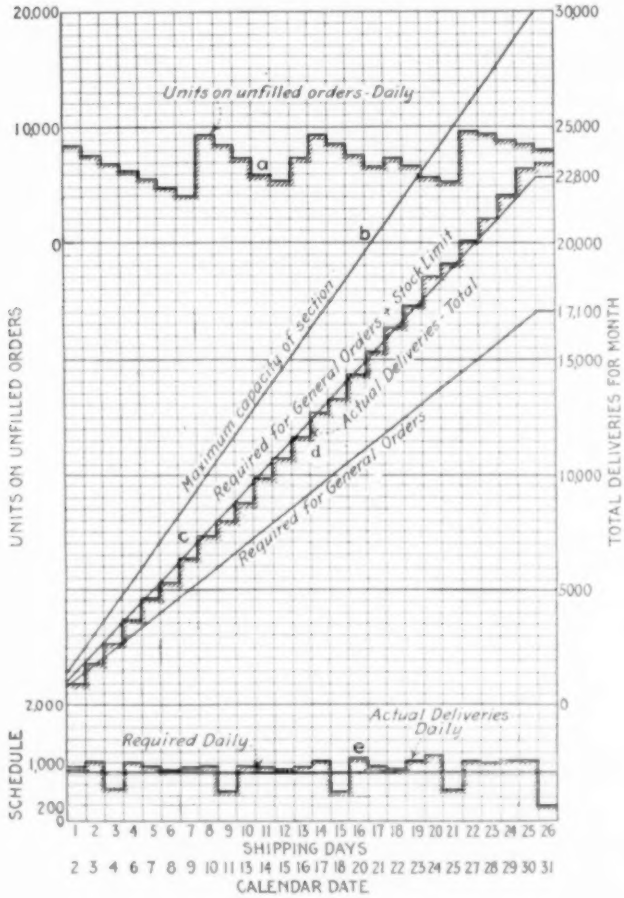


FIG. 3 LOAD DIAGRAM

ance. Anything in excess must first receive the approval of the superintendent of the department.

Handling Materials: Considerable study has developed economical means for handling smaller materials, as for example misprint cloth bags in place of paper wrappings; for larger material metal tote boxes without wheels or with telescoping wheels. For transporting, standard gage steam and narrow gage electric storage battery cars and hand, platform lifting and electric storage trucks are used. These latter have proved very profitable as labor savers. A central oil storage warehouse has been established with pipe lines to each building. A further development will be the delivery within the building of oil from an electric truck, and this method could be worked out advantageously for inter-department delivery of material. Mail is handled from a central post-office through pneumatic tubes to the principal departments.

Safety Methods: Well-defined steps have been taken for the systematic introduction of safety methods and devices. A supervisor of safety appliances was appointed and a monthly appropriation issued to cover the cost. No new tools are erected nor old tools replaced without adequate safeguards, by which means dangerous tools or equipment are gradually eliminated. An analysis of the accidents for the past year shows but three-tenths of 1 per cent to have been caused by the absence of safeguards. By far the largest percentage, namely, 21½ per cent, were due to the carelessness of the injured themselves, so it means a campaign of education must be undertaken. This is being accomplished in several ways as for example, through the medium of small yet prominent Safety First metal plates which have been placed in a prominent position on every machine. Signs bearing this and similar legends have been recently standardized by several national societies, among them Founders, Manufacturers, Metal Trades, and Electric Light. Lectures are also given to workmen which are repeated to the same persons at intervals of six months.

Inactive Materials: All stock ledgers are regularly scrutinized by the storekeeping department and slow-moving or inactive items submitted to a materials disposition department that investigates not only the cause of the inactivity with a view to preventing a recurrence, but at the same time endeavors to dispose of the material to the best advantage.

DISCUSSION

H. B. LANGE said in a contributed discussion that to appreciate the field of opportunity for standardization it is to be noted that many works organizations maintain engineers who make this work their sole function. It has been often demonstrated that on repetitive work low costs can be accomplished by reducing all product to a unit basis without reference to the final assembly. Where working within limits of allowable variations it would seem advisable to draw one part only on a subdivision of a drawing sheet preferably of letter sheet size—with a separate part list and an arrangement drawing giving the assembly information. Proper filing and classification of prints of drawings assists in selection of parts already in use and revealing parts of similar character which might be consolidated for standard adaptation. The cost of drawings is negligible compared with accrued benefits. Mounting prints on strawboard and keeping them filed when not in use is economy. Standardization can be furthered by a showing on a letter size sheet the part with a list below of the differing dimensions. This is especially applicable to purchased parts used, and these bound together give a simple and condensed means of imparting essential information. In fact this same size sheet and the letter dimension scheme extended to parts made in the shop is worthy of consideration.

L. D. BURLINGAME said the paper illustrates the transition from the old-time method when the man in charge knew every part and could adjust all parts to make a completed

unit to the new method of making parts from a carefully prepared drawing with sufficient information thereon so that when assembled the final unit will come together satisfactorily. It brings out, further, the present time method of manufacturing parts in large quantities at one time and having them available when needed.

The matter discussed in the paper of how to show dimensions on drawings should be determined by adopting whichever way produces the best result depending on the class of employees but the gage system marked in decimals should be used in figuring drawings.

OPERATION OF GRINDING WHEELS IN MACHINE GRINDING

BY GEORGE I. ALDEN, WORCESTER, MASS.

Member of the Society

Long experience in the use of grinding wheels has developed facts in regard to their action, which, however, have been stated only as empirical rules. Such rules are easily forgotten or confused by operators because they are not related in any obvious way to any known principles by which results may be predicted. For example, what is the effect upon a wheel of increasing the speed of work, or of increasing the diameter of the work, or of diminishing the diameter of the wheel?

This paper gives an analysis of the action of the wheel when in operation. It shows the distinction between the radial or real depth at which the wheel cuts and the depth which the abrasive grain in the wheel cuts into the material being ground. This latter depth is termed the "grain depth of cut," which is the *controlling factor* in securing the correct working of the wheel. This grain depth of cut is indicated in Fig. 1, where

C = the center of the wheel
c = the center of the work
OP = the radial depth of cut
OQ = the arc of contact of wheel and work.

Owing to the revolution of the wheel and work, a cutting point O on the wheel will move to Q in a certain time and a point Q on the work will move toward P to some point as W. The chip removed is represented by OQW and the *grain depth of cut* is WS.

When a grinding wheel is working properly, the abrasive grain of the wheel may be considered as cutting small chips from the work, and the surface of the work as cutting or wearing away the bond of the wheel. It is quite evident that the greater the grain depth of cut, the more effective will be the action of the work upon the bond of the wheel. So long as the bond is being worn away just as fast as the abrasive grains of the wheel are being worn down, the wheel will continue to work well. If the bond is cut away too rapidly, the wheel will appear too soft, and will wear away too rapidly. If the cutting grains wear down faster than the bond is cut or worn away, the face of the wheel will become glossy, and the wheel will not cut freely. These considerations lead directly to the conclusion that the action of a given wheel on a given kind of work is almost entirely dependent upon the grain depth of cut. If the grain depth is too great, the wheel wears away too rapidly. If the grain depth is too small, the wheel may glaze.

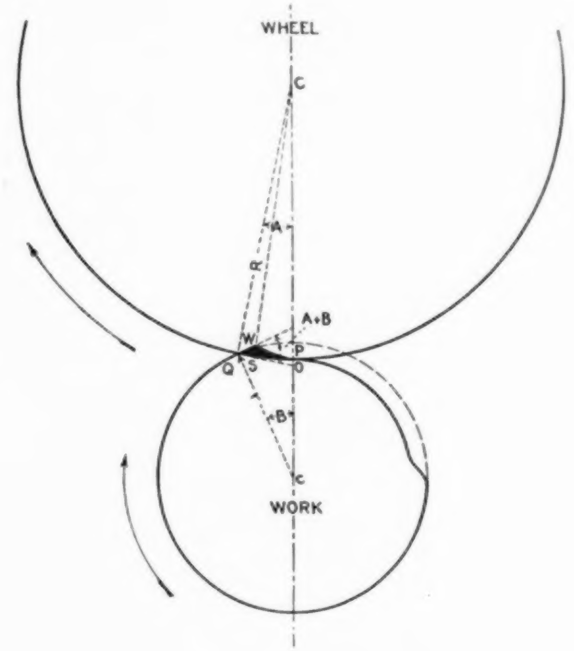


FIG. 1

It is therefore important to know how the grain depth of cut may be regulated.

As is evident from Fig. 1, one relation that affects the grain depth of cut is the ratio of the work speed to wheel speed, represented by QW and OQ. It is also affected by changes in diameter of wheel or work. Assuming

a Other factors remaining constant, increase of work speed increases grain depth of cut, and makes a wheel appear softer

b Similarly, a decrease of wheel speed increases grain depth of cut

c Similarly, diminishing the diameter of the grinding wheel increases grain depth of cut, and increasing the diameter of the wheel decreases grain depth of cut

d Similarly, making the diameter of work smaller increases grain depth of cut. Conversely, making the diameter of work larger makes grain depth of cut smaller

In applying the principle that grain depth of cut is the main factor, the correct relative speeds of work

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Abstract of paper presented at Annual Meeting, December 1914. Complete paper may be obtained without discussion, price 5 cents to members; 10 cents to non-members.

and of wheel must be found by trial for each wheel and each kind of work. When this has been done, the principle of grain depth of cut will enable one to know the direction in which to make the changes of work speed or wheel speed, to adapt the wheel to changes in its own diameter, or to other sizes of the same kind of work.

In the foregoing it is assumed that the object of grinding is to remove stock rapidly. Often, however, the character or finish of a ground surface is of primary importance. From the point of view of grain depth of cut, a smooth surface by grinding would be obtained if the grain depth of cut were very small, and therefore the work speed should be relatively slower for finishing than for roughing. That the bond may be worn away by a very small grain depth of cut, a softer wheel would be used for fine finishing than for roughing. A very hard glazed wheel may sometimes produce a mirror-like surface on the work; the action in this case being a sort of burnishing process.

The following formula expresses the grain depth of cut:

$$d = \frac{v}{Vn} \sin (A + B)$$

where

- v = surface velocity of work
- V = surface velocity of wheel
- n = number of cutting particles per unit length of circumference of wheel.

In the paper a table is given of arcs of contact for different diameters of wheel and work, and examples are worked out to show the change in grain depth of cut due to changes in radial depth. These show that increase of radial depth does not increase grain depth in the same proportion. In one case, doubling the radial depth increased grain depth only 40 per cent. If, however, sin $(A + B)$ is increased, say 40 per cent by doubling the radial depth, the formula shows that v/V might be diminished by about 30 per cent without changing the grain depth; but these changes, which have not varied the theoretical value of grain depth d have increased the rate of production 40 per cent. This indicates that production may be increased without increasing grain depth of cut, by increasing the radial depth of cut, and at the same time diminishing the work speed a less per cent than the radial depth is increased. In practice this method of increasing production requires rigidity of machine and work.

DISCUSSION

C. H. NORTON said that he wondered whether those interested had got the thought which the author offered. It has to do in the operation of grinding machines with the selection of the speed of the work for a given radial depth of cut. The paper indicates that the production may be increased by slowing the working speed and increasing the radial depth, without destroying the wheel as rapidly as if it were attempted to cut to a greater depth or with a rapid revolution of the work.

THE AUTHOR, in answer to an inquiry by M. D. Hersey as to the effect of pressure of the wheel against the work, said, that for a given radial depth of cut, the pressure depends on the condition of the wheel. If the wheel cuts badly the pressure is heavy and vice versa. The faster the work is worn down the faster it wears away the bond, the friction between the work and wheel is large and pressure becomes greater.

In response to further inquiry as to the importance of the rigidity of support of the grinding wheel and its rigidity in the bearings, it was brought out that the life of the wheel and the amount of effective work and the rapidity with which it produced are dependent upon rigidity. Mr. Norton said that he used very carefully made bearings and that they were fitted to a degree of nicety where the ordinary engineer would condemn them because they ran hot. A thin lubricant is used and good results are secured.

FRICTION LOSSES IN THE UNIVERSAL JOINT

BY P. F. WALKER, LAWRENCE, KANS.
Member of the Society
AND W. J. MALCOLMSON, LAWRENCE, KANS.
Non-Member

During the past three years two standard makes of universal joints have been under observation and test in the laboratory of the Mechanical Engineering Department of the University of Kansas, with the object of determining the loss of power due to friction in the joint while operating under such loads and speeds as are common in automobile service. In each case two complete joints connected by an intermediate shaft were employed, so that in service during the tests power was transmitted through the set from the primary shaft to a parallel secondary shaft, Fig. 1. All observed data relate therefore to the loss occurring in two joints. The main dimensions were as follows:

	Joint No. 1	Joint No. 2
Diameter intermediate shaft.....	$1\frac{1}{2}$ in.	$1\frac{3}{4}$ in.
Length of shaft................	22 in.	13 in.
Dimensions of each bearing.....	$\frac{3}{4}$ x $\frac{3}{4}$ in.	$1\frac{5}{16}$ x $1\frac{7}{16}$ in.
Maximum angle of deflection....	15 deg.	14 deg.
Horsepower rating..............	16 h.p.	30 h.p.
Lubricant used..................	hard grease in each	

The kinetic relationships embodied in the universal joint is such that the driving and driven shafts must be parallel in order to secure a uniform velocity ratio. If the second shaft makes an angle with the first, it will have a variable velocity, the extent of which will depend upon the size of the angle.

Further, in assembling the joints, the forks on the

Abstract of paper presented at Annual Meeting, December 1914. Complete paper may be obtained without discussion, price 10 cents to members; 20 cents to non-members.

intermediate shaft should be in the same plane. This point is not appreciated by the average person using universal joints, about half the joints being wrongly assembled with the forks on the intermediate shaft at 90 deg. or some other angle to each other. This gives rise to unsatisfactory operation and the joints of the machine are often indiscriminately condemned.

The actual determination of the friction losses in

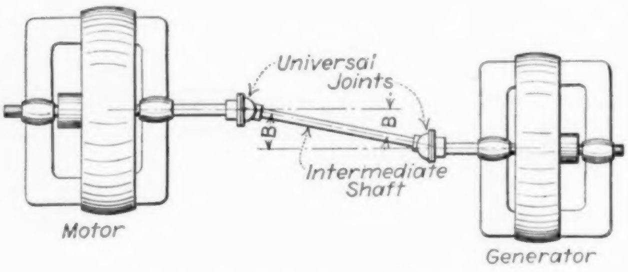


Fig. 1 Arrangement of Machines

universal joints, such as are used in automobile power transmission, under proper conditions of speed and load requires extreme delicacy and care. The difficulty in this problem lies in the fact that the amount

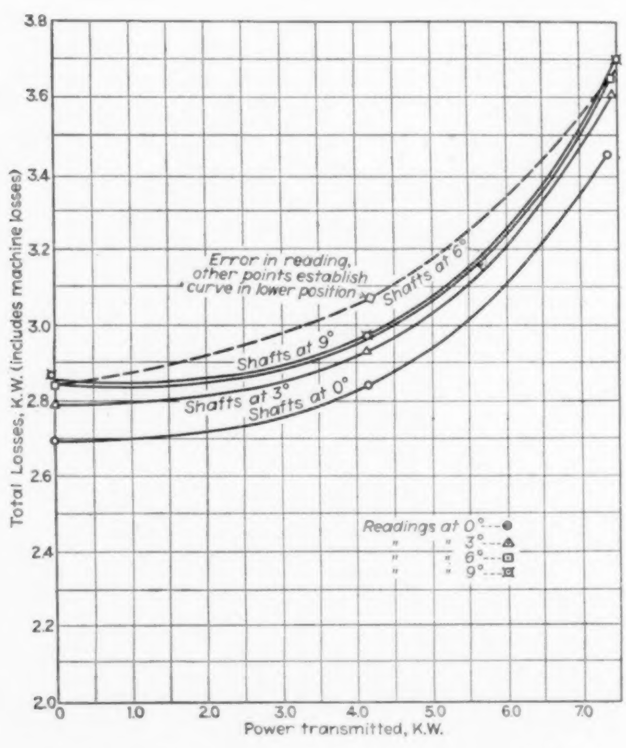


Fig. 2 Joint No. 1. Forks in same Plane, 800 R.P.M.

of power dissipated in the joint, as friction loss, is very small compared with the amount of power transmitted. Practically the only way to measure the loss in the joints is to determine the power delivered to one of the shafts and the power delivered by the other end. The losses would then be the difference between the input and the output. As these two quantities are comparatively large and nearly equal, any small error in their determination would produce a relatively

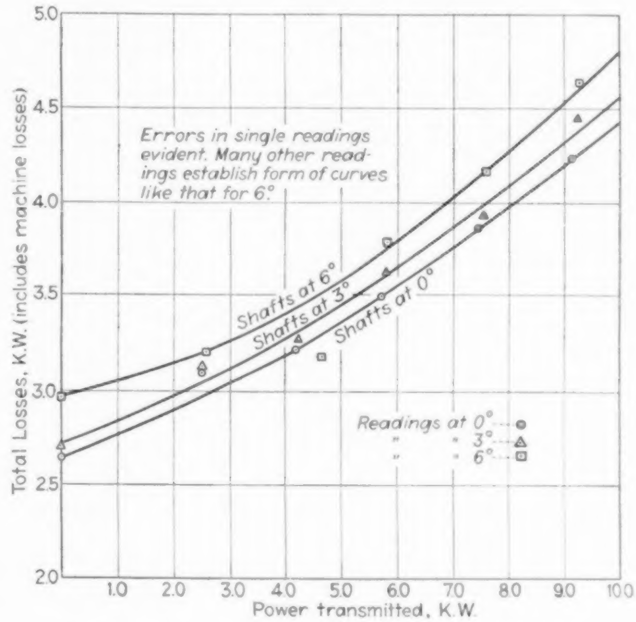


Fig. 3 Joint No. 1. Forks at 90 Deg., 800 R.P.M.

large error in the derived value of the loss. In the actual performance of any experimental work to determine this loss of power in the joints as friction, the problem becomes that of measuring accurately the power supplied to, and that received from the section of shafting which includes the joints.

In considering the several possible methods of meas-

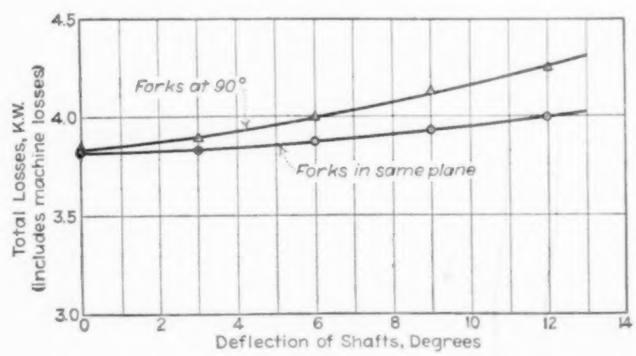


Fig. 4 Joint No. 1. Constant Load, 800 R.P.M.

uring the power transmitted by line shafting the accuracy required to determine the relatively small value of the friction losses in the universal joints put the general class of dynamometers out of the question, and it was early decided that to obtain any accuracy whatever with the facilities and time available, electrical methods should be used throughout and it was decided to use the Puffer Modification of the Kapp Load-Back Method of Testing, as described in Foster's Electrical Engineer's Pocket Book (1908 ed.).

Briefly, in this method of testing two machines, preferably of the same size, make and rating, are both electrically and mechanically interconnected. One machine operates as a motor and drives the other mechanically as a generator. The current generated by the generator is loaded back on the motor supply line. Since one machine takes power as a motor and the other returns power as a generator, the net power taken from the line is only that which is required to supply the total losses of the system.

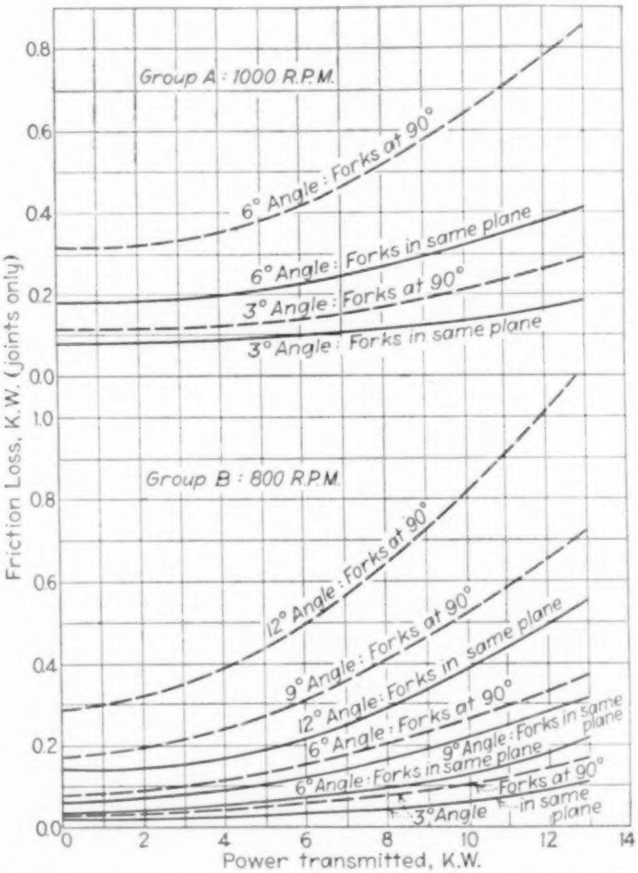


FIG. 5 FRICTION LOSS AT VARYING ANGLES. VALUES DERIVED FROM AVERAGES

The actual procedure in carrying out the experiments consisted in first running the machines with all shafts in the same straight line and determining the total losses of the system as a whole. With the main shafts kept parallel, and keeping as nearly constant as possible all other conditions, such as speed, temperature, lubrication, and general conditions, the losses of the system were again determined for a certain angular displacement of the intermediate shaft. Readings were taken at different angular displacements and similar runs were then made for various speeds and loads. Experiments were made for both sets of joints both with the forks on the intermediate shaft at 90 deg. to each other and with the forks in the same plane. Assuming, correctly, that the losses in the joints are zero for conditions of straight line drive, with all other conditions remaining the same, the friction losses for a certain displacement of the intermediate shaft would be found by subtracting from the total losses of the system at that displacement the total losses under conditions of straight-line drive.

With the forks at 90 deg., there was noticeable a distinct vibration and knocking which was not pres-

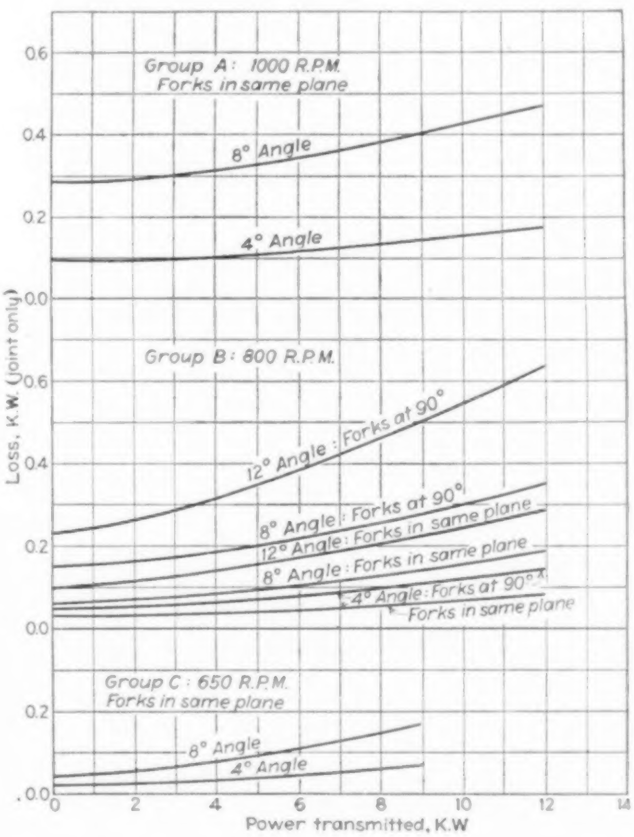


FIG. 6 JOINT NO. 2. FRICTION LOSS AT VARYING ANGLES, VALUES DETERMINED FROM AVERAGES

ent when the joints were properly assembled. This vibration increased as the angle of deflection increased, sometimes becoming so pronounced for the larger angles that it was found to be unsafe to try to operate.

Two general methods for securing readings which should cover variations, both in load and angle of inclination were followed. One consisted in lining the shaft exactly for straight-line drive and under this condition of zero loss operating the joint through a wide range of loads. This being done, the driven machine would be offset to give any desired angle and the apparatus then be operated through exactly the same range of loads, speed being held constant for all conditions.

The other method consists in holding both speed and transmitted load constant during the entire se-

ries of observations. In this case, with the shafts in direct line for straight-line drive, the initial value of total loss corresponding to zero loss in the joint is determined. After this, with the machines still running, the generator would be moved to give the proper offset angle and the readings for that condition taken with but a few moments delay. This would be repeated for as many angles as desired.

Figs. 2, 3 and 4 show curves which represent the individual readings of total losses, and Figs. 5 and 6

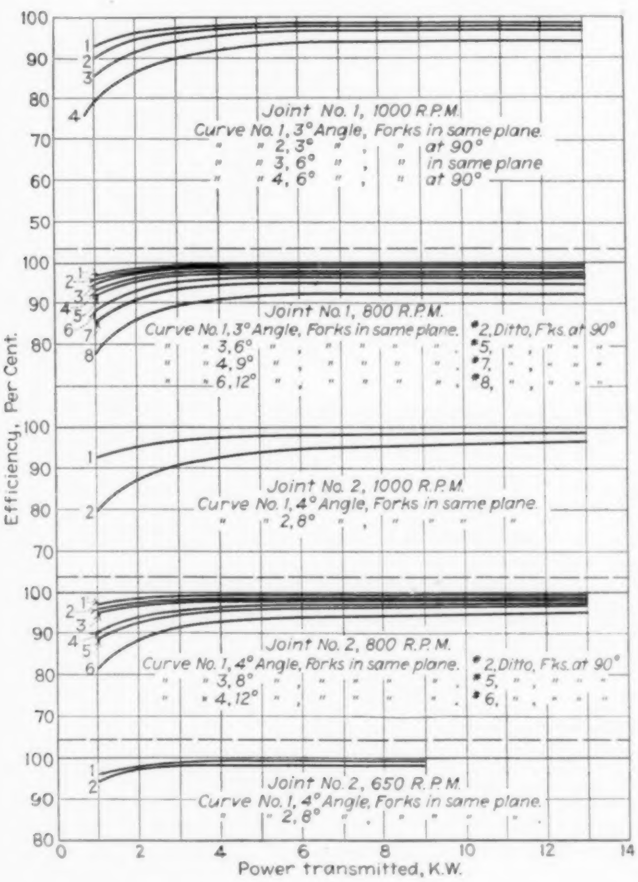


FIG. 7 EFFICIENCY CURVES

are curves showing the true friction loss. Fig. 5 pertains to joint No. 1 as operated at the two speeds of 1000 and 800 r.p.m. Fig. 6 gives corresponding information for joint No. 2. They represent the final results of all of the work and are located by points which are fixed by taking averages of many observations. In changing from the basis of total losses to friction loss in the joints alone, the total loss for zero angle was first deducted from all other values of total loss, determined during that particular day's work. All such differences, each representing a loss due to angularity, were then cast onto one common base line and a single representative curve established for each angle investigated. It did not seem necessary to extend the work to secure data for all conditions of load and speed for the joints improperly assembled with the joint forks set at 90 deg. on the intermediate shaft. Enough was done to demonstrate the necessity of assembling properly.

In the calculation of efficiency of the joints it seemed wise to make the conclusions applicable to a complete system including the two joints necessary to secure parallel operation of the main shafts. In case a knowledge of the efficiency of a single joint is desired, it may be assumed without sensible error that the loss is one-half of the amount here recorded and that the efficiency would be indicated for each condition by a fraction which is the arithmetical mean of the figure here given and unity. The difference between the amounts of power transmitted by the two joints is so small as to be outside any possible limits of observation.

The efficiency is calculated directly from the curves of derived values of friction loss. For any power and angle the friction loss in the two joints is read. The power is, in all cases, the amount transmitted at the joint, it being the sum of the load delivered by the driven generator and the losses of that machine. These latter losses have been based on separate tests made to determine the machine characteristics. It follows, therefore, that efficiency equals the power transmitted divided by that power plus the friction loss; that is, it is power delivered divided by power received by the joints.

Fig. 7 shows the efficiencies of the universal joint sets in the various conditions of operation. From these curves it is noted that for loads amounting to one-half the rating of the set, or more, the efficiency is nearly constant and the loss very small for angles of inclination not exceeding 6 deg. For larger angles the loss becomes an appreciable amount. The constancy in the efficiency fraction indicates a constant value of the coefficient of friction on the joint journals, since the bearing pressures are proportional to power transmitted while speed remains constant. Under conditions of service the questions of lubrication and protection from dust are important. In the efficiency calculation a downward tendency was noticeable at the largest loads although it is not visible on the curves. Doubtless it marks the point where the bearing pressures on these journals make lubrication imperfect. The rocking motion of the journals tends to squeeze out the oil.

RAILROAD SESSION

REPORT OF SUB-COMMITTEE ON RAILROADS AND CONTRIBUTED DISCUSSION

AT the Railroad Session of the Annual Meeting, Wednesday afternoon, December 2, a report was presented by the Sub-Committee on Railroads on Steam Locomotives of Today, which outlined the principal features of the locomotive problem as it now appears to railway mechanical officials. The subject was topically arranged, and each of the topics was discussed, some of the contributed discussions being exhaustive in character and of more than ordinary interest. The report of the Committee, which was brief, is reproduced in complete form below, while the discussions are presented in abstract form.

STEAM LOCOMOTIVES OF TODAY

Recent progress and improvement in the efficiency and capacity of steam locomotives has been of such remarkable character and extent that a record in the proceedings of this Society is justified.

Steam and electric locomotives as rivals in the same field has been a favorite subject for discussion before engineering societies, and it is easy to start arguments in favor of each of these rivals among the partisans interested. Whether or not the steam locomotive is to be displaced by the electric is, of course, an important question which will in time be settled by the court that settles all such questions, that of the treasurer's figures. For the present and for the immediate future the burden of transportation falls and will continue to fall upon the steam locomotive. If the steam locomotive is to be perpetuated it is fitting that it should be improved to the utmost limit. If it is to be finally displaced it is fitting that it shall be so improved in order that progress to something better shall be intelligently developed upon a solid foundation. This discussion will be confined to the steam locomotive, its progress in the recent past and its possibilities for the near future.

PROGRESS IN CAPACITY

While efforts individual in character and extent were made in this country before that time, the first consistent and systematic plan to secure the utmost power of locomotives within given restrictions of weight and cross-section clearance was inaugurated 20 years ago. This plan began with an eight-wheel or American type passenger locomotive, built for an eastern railroad in January 1895. This locomotive weighed 116,000 lb., with 74,500 lb. on driving wheels. It provided a tractive effort of 21,290 lb. While this locomotive was not the most powerful in passenger service at that time, it was the first of a chain of passenger locomotives leading in a connected series, by the same builders, up to and including recent designs of the Mountain type, representing the largest passenger type of present practice. This type has four-wheel leading trucks, eight driving wheels and two trailing wheels. The largest of the Mountain type weighs 331,500 lb. with 240,000 lb. on driving wheels and produces a tractive effort of 58,000 lb., or about three times the tractive effort of the first design of the series built during a period of 20 years.

In the year 1898 the engineering and railroad world was interested by the appearance of the largest and most powerful locomotive built up to that time. This was of the Consolidation type with a two-wheel leading truck and eight driving wheels. This locomotive was built in Pittsburgh and for a number of years was the largest and most powerful of its type, and the largest and most powerful locomotive in the world. Its total weight is 230,000 lb., weight on drivers 208,000 lb. and tractive effort 53,300 lb.

Today the most powerful freight locomotive has two leading and two trailing wheels and 24 driving wheels. It gives a tractive effort of 160,000 lb. and weighs 410 tons. This locomotive has hauled a train of 251 freight cars weighing 17,912 tons, exclusive of the locomotive. The total length of the train was 1.6 miles, the maximum speed attained was 14 miles per hour. This required a maximum drawbar pull of 130,000 lb. This locomotive has six cylinders and three groups of driving wheels.

A freight locomotive has recently been built having two cylinders and a single group of driving wheels which develops a tractive effort of 84,500 lb. Such has been the progress in capacity.

This progress has been rapid, perhaps somewhat too rapid with respect to improvements in operating facilities and progress in other features of railroad equipment. It has been rendered possible by corresponding developments of factors making for greater efficiency in boilers and in engines. During the past 20 years in this country locomotive development in capacity and in efficiency, particularly during the past five years with respect to efficiency, has been remarkable and is worthy of record with progress in marine and stationary engineering.

In Europe the relatively high cost of fuel led to efforts to improve efficiency before this problem aroused serious attention in this country, but physical limitations more rigidly restricted the size and weight of

locomotives in Europe. Our problem is to secure maximum efficiency combined with great size, great weight and great power which is more difficult. Since the development in the size and weight has been tremendous, even though these limits may not yet have been reached, it is now appropriate to concentrate on efficiency.

For a number of years the physical capacity of the fireman to shovel horsepower through the fire door determined the capacity of the locomotive at speeds. Mechanical stokers have removed that limitation. It is now possible to fire six tons, and more, of coal per hour into a locomotive firebox. This has changed the problem into one of getting the maximum amount of heat out of the coal and using it economically in the cylinders. With the large figures now prevailing for drawbar pull and weight it is fitting that closest attention should be given to the best possible use of every pound of metal and every pound of coal. Due to recent application of several economy producing and capacity increasing factors great improvements have already been made with promise of more to come. Then the great work of building up the efficiency of the average locomotive to the standard of the best will follow in natural course.

Among these economy producing and capacity increasing factors are the following improvements:

- Boiler design in relationships of the factors making up heating surface
- Firebox design
- Front end design, draft appliances, exhaust nozzles
- Ashpan design as to air openings
- Superheating
- Compounding
- Feedwater heating
- Firebrick arches and circulating supporting tubes
- Valve gear
- Detail design to secure reduced weight of reciprocating parts and other parts
- Use of high-grade alloy steels to reduce weights
- Mechanical stokers
- Labor-saving devices for the engineman and fireman
- Improved counterbalancing to permit of greater weight on driving wheels by reducing dynamic stresses
- And yet to come is powdered fuel with possibilities unknown in scope and in importance. Powdered fuel is in reserve, promising the ideal method of complete combustion under control more perfect than is possible with present methods other than oil burning and perhaps with economies impossible to obtain with oil.

PROGRESS IN EFFICIENCY

Valuable comparisons may be drawn from the best results of ten years ago and of today. At the Louisiana Purchase Exposition in 1904 the tests made by the Pennsylvania Railroad revealed important figures concerning locomotive performance at that time. It was shown to be possible to obtain equivalent evaporation from and at 212 deg. of 16.4 lb. of water per sq. ft. of heating surface, indicating the power of locomotive boilers when forced. It was shown that when the power was low, the evaporation per pound of coal was between 10 and 12 lb., whereas the evaporation declined to approximately two-thirds of these values when the boiler was forced. These results compared favorably with those obtained in good stationary practice, whereas the rate of evaporation in stationary practice lies usually from 4 to 7 lb. of water per ft. of heating surface per hour. In steam consumption the St. Louis tests showed a minimum of 16.6 lb. of steam per i.h.p. per hr. In coal economy the lowest figure was 2.01 lb. of coal per i.h.p., the minimum figure for coal per dynamometer h.p. was 2.14 lb. These records were made after the superheater had become a factor in locomotive practice and they represent economies attained by aid of the superheater in one of its early applications. This is important in the light of the recent development of the superheater. These remarkable figures have never received the attention which they deserve from engineers. They serve, however, to show that 10 years ago a steam locomotive had attained results which were worthy of the best attention of the engineers of the time. Since then greater progess has been made and today locomotives of larger capacity than those concerned in the St. Louis tests have given better results.

Voluminous records of recent investigations of locomotive performance taken from the Pennsylvania Railroad test plant at Altoona show that the best record of dry fuel per i.h.p-hr. down to the present date is 1.8 lb. with a large number of less than 2 lb., while the best performance in dry steam per i.h.p-hr. is 14.6 lb. with a large number less than 16 lb. A reduction of 10 per cent in fuel and 12 per cent in water is remarkable as a result of a development of 10 years. This coal performance was recorded by a Class E6S Pennsylvania Railroad locomotive while running at 320 r.p.m. and developing 1245.1 i.h.p. The same locomotive gave a fuel rate of 1.9 lb. while running at the same speed and developing 1750.9 i.h.p The best water rate was given by Class K2Sa Pennsylvania Railroad locomotive while running at 320 r.p.m. and developing 2033.1 i.h.p. These high powers indicate that the locomotives were not coddled as to output of power in order to show high efficiencies, but that high efficiencies accompany actual conditions of operation in severe service. As to power capacity expressed in terms of evaporation, it is interesting to note that the maximum equivalent evaporation from and at 212 deg. per sq. ft. of heating surface per hour on the Altoona test plant is 23.3 lb. These figures of high efficiency were obtained from locomotives which represented not only very careful, general and detail design, but their design included several of the improvements making

for greater capacity and higher efficiency, without which the results could not have been attained.

Having in mind the facts that steam locomotives are power plants on wheels, built to meet rigid limitations of weight, both static and dynamic, and that the use of condensers is impossible, engineers in general must admit the high character of the work of locomotive designers which has attained these results.

Greater efficiency which is revealed on the test plant and through reports of engineers would be important because it proves that progress is being made in the possibilities of locomotive performance. Improvement which is revealed by operating statistics and which, therefore, appears in the records of the treasurer's office is the real test in this case. It is important to know that increased power of locomotives attained largely through the development of economy producing and capacity increasing factors has produced results which the financial reports of railroads prove beyond question. A recently published list of train tonnage on 45 prominent railroads indicates that 16 of these roads have increased their average freight train loads by over 30 per cent during the last five years. Credit must be given to the improvement in the locomotive for most of this development. These figures reveal the value of increased power and efficiency of steam locomotives and the end is not yet in sight.

WHAT REMAINS TO BE DONE

American locomotive development to its present state would have been impossible without the use of the improvements already mentioned. It is believed that all these are capable of still further development, making for still greater economy in the use of fuel and, therefore, promising greater power capacity. It is the object of your Committee to present these possibilities for discussion by those who are engaged in perfecting and improving steam locomotive practice in this country. It is the hope of your Committee that engineers who are devoting their attention to the design of locomotives as a whole and those who are engaged in the development of the various details which have contributed to the high efficiency of the steam locomotive of today will discuss the progress of the recent past and reveal possibilities for future development and improvement in capacity and efficiency.

G. M. Basford
F. H. Clark
W. F. Kiesel, Jr.
Sub-Committee of Railroad Committee

ABSTRACT OF DISCUSSION

F. F. Gaines contributed a written discussion in which he stated that boiler and firebox proportions must be carefully studied and chosen so as to produce capacity as well as efficiency. These proportions are now being worked out on a scientific basis. Modern large engines have a ratio of tube heating surface to total heating surface as high as 20. On small engines with deep fireboxes this ratio formerly ran as low as 8. A desirable figure for this ratio is 12. This can be obtained by the use of a combustion chamber which lengthens the firebox and shortens the flues. Where large grate areas are required, as in the large Erie Triplex, it is almost impossible to provide a wheel arrangement that would not necessitate the firebox extending over the drivers. With the use of a combustion chamber this can easily be accomplished, as the mud ring may be as high or higher than the bottom waist line of the boiler. The ratio of total heating surface to grate area should not be over 80, and more economical results are obtained if it is 65.

With ample grate area and firebox heating surface the desired results cannot be obtained unless the affiliated parts are correctly designed. The grates should be of such mesh as the grade of fuel requires; the mesh being as large as possible without the fuel dropping through. The grates should also have the maximum of possible air openings as well as air openings in the side bearers. The opening on the top should be a minimum and expand as it goes down, so that any ash, slate or clinker that can pass through the top will easily pass through and not clog the grates. Ashpan openings are generally restricted and do not admit sufficient air for economical or maximum combustion. The proper arrangement of front ends is very essential to the uniform drafting of the fire; the lower the exhaust pipe, the less the back pressure and consequently the greater the mean effective pressure.

In this country feedwater heating is confined to a limited number of cases and cannot be said to be recognized generally as a factor in fuel economy. Experiments made on several engines by the writer showed about 10 per cent economy, which was considerably offset by difficulties in maintenance. Eventually, however, we will develop a type of feedwater heater that will eliminate the objections. It would appear that the most feasible plan would be a type of open feedwater heater, which would be located between the frames of the engine and underneath the boiler, using the exhaust from the air pumps, boiler feed pumps, and part of the main exhaust. In doing this it is thought that ultimately instead of using the present form of exhaust draft to effect combustion, with its consequent back pressure due to restriction of nozzle, a form of forced draft of the blower type will be used. Under these circumstances the exhaust openings from the cylinder to the atmosphere can be made without any restriction whatever, thereby greatly eliminating back pressure. The steam required for operating the auxiliary and forced draft would use but a small proportion of the horsepower gained. Previous experiments would also indicate that a type of centrifugal pump would be much more effective and positive for boiler feeding than one of the reciprocating type.

American railroad practice is averse to adding anything to the locomotive in the way of additional apparatus which complicates its operation or adds to its complexity. The demand for the utmost economy will eventually bring about a satisfactory method of feedwater heating so that in connection with superheating, liberal firebox heating surface,

and possibly compounding, we can obtain the maximum possible economy from the fuel used.

F. J. Cole called attention in a written discussion to the fact that in recent years, locomotives have increased so much in power that methods formerly employed are no longer adequate in proportioning the grate, heating surface, length and diameter of tubes, etc., when the class, tractive power and limitations of weight are known.

The size of cylinders is usually fixed by the permissible axle load allowed upon the track or bridges, in connection with the type, driving wheel diameter, boiler pressure and factor of adhesion. After these fundamental features are decided upon, the boiler proportions must be outlined to see whether the required amount of heating surface can be obtained without exceeding the limits of weight.

There are two general questions involved in the consideration of this subject, namely, how many pounds of steam per hour are required to supply the cylinders in order to develop the maximum horsepower; and what proportion of grate, firebox and tube heating surface will best produce this amount of steam.

The locomotive, unlike most steam plants, varies in the speed and power developed. It must be able to run at any intermediate speed between starting and its full velocity and at the same time develop all degrees of tractive power within its capacity. At slow speeds the maximum pull must be exerted in order to start the trains easily, and for this reason the live steam is admitted to the cylinder during 80 to 87 per cent of the stroke. As the speed increases it is necessary to reduce the admission period, thereby increasing the expansion of the steam. Therefore for any speed there is some point for the valves to cut off the live steam, at which the engine will develop its maximum power. There is also some minimum velocity at which the full horsepower of the locomotive is attained; after this velocity is reached the horsepower remains constant or slowly decreases. This critical point may be taken at 700 to 1000 ft. per minute piston speed.

It has been customary to use certain ratios, based on cylinder volume, for locomotive proportions. These ratios left to individual preference such matters as rate of combustion per square foot of grate, length of flues, evaporative value of firebox heating surface or value of tube or flue heating surface in relation to the length, making it desirable to proportion boilers upon more uniform methods in which these variable factors are given due consideration.

The writer collected a considerable amount of data on this subject and drew up a report with the object of reducing this matter to a more uniform basis, substituting for the ratios hitherto employed, cylinder horsepower requirements. Suitable values were assigned to grate surface, tube heating surface, etc., with corresponding evaporative values, so that the balance between the amount of steam required by the cylinders and the amount of steam which the boiler was capable of generating could be expressed in percentage of cylinder horsepower. The tests made on sectional boilers on the Northern Railway and the Paris, Lyons & Mediterranean Railway of France, those of Dr. Goss on a Jacobs-Shupert boiler, and tests by the Pennsylvania Railroad on the Altoona testing plant were examined in order to obtain data on which to base the evaporative values of different points of the boiler. It is obvious that the evaporative value of a boiler tube of given diameter varies greatly with its length. The temperature of the firebox is fairly constant under similar conditions of draft and rate of combustion, therefore the temperature of the smokebox will be reduced with an increase in the tube length. While some additional draft will be required to draw the gases through the tube, yet the net result is a greater temperature absorption between the firebox and smokebox. The thermal efficiency of the engine is increased within certain limitations by the use of long flues. The economical length of tube is determined mostly by the number and arrangement of wheels of the engine required and only partly by thermal conditions.

About 1899 the wide firebox Atlantic (4-4-2) type was introduced. Because the firebox was placed behind the driving wheels, the grate surface could be made to suit the power of the locomotive. It was, therefore, no longer necessary to force the rate of combustion as heretofore to 180 and 200 lb. per sq. ft. per hour. Very uneconomical results had been obtained when high rates of combustion were necessary, as much unburned coal was drawn through the tubes into the smokebox and thrown out through the stack by the violent draft. With the Atlantic, tubes of 15 and 16 ft. and sometimes longer were necessary. While at first some apprehension from leakage was felt with tubes of this length, it was soon found that there was no more difficulty in maintaining long tubes in good condition than short tubes. With the introduction of the Pacific (4-6-2) type, the Mikado (2-8-2) type and other locomotives having trailing trucks, still longer tubes were required. Tests made on long tube boilers, compared with older locomotives having shorter tubes, showed a noticeable reduction in smokebox temperatures.

Instead of the old arbitrary and unsatisfactory method of designing heating surface by cylinder ratios, the idea of using the cylinder horsepower suggested itself as forming a very desirable basis. Curves were prepared from the most recent available data showing speed factors or drop in m. e. p. in relation to velocity. With saturated steam the average maximum horsepower is reached at about 700 ft. piston speed per minute, speed factor 0.412; constant horsepower is obtained at 700 to 1000 ft. piston speed, and then slightly decreasing at higher velocities for average conditions when engines are especially constructed for the highest speeds. For superheated steam the average maximum horsepower is reached at 1000 ft. piston speed, speed factor 0.445 and constant horsepower at higher speeds. Because the horsepower is based on piston speed, the stroke and diameter of wheels are omitted in the following figures, the calculation for saturated steam becoming by cancellation:

$$\frac{0.85\ P \times 0.412 \times 1000 \times 2A}{33{,}000} = 0.0212 \times P \times A$$

in which

A = area of one cylinder in sq. in.
P = boiler pressure
0.412 = speed factor

In a similar manner the horsepower calculation for superheated steam becomes

$$\text{h.p.} = 0.0229 \times P \times A$$

using 0.445 as the speed factor.

The maximum horsepower can sometimes be increased when the locomotive is operated under the most favorable conditions. It is considered safer to take figures which

represent average conditions rather than the unusual figures obtained when all conditions are most favorable.

The horsepower basis affords many additional advantages in designing locomotives. For instance, in determining the maximum amount of water and coal required per hour, the size of the grate is found to be proportional to the amount of coal that can be burned to the best advantage, to be varied according to the quality. Knowing the amount of coal required per hour directs attention to the question of hand firing or the use of a mechanical stoker. Knowing the amount of water evaporated per hour determines the location of water stations, size of tender and tank, and also forms the basis for other features of the boiler, such as stack, size of injectors, safety valve capacity, and the size of steam pipes.

From the reports of Pennsylvania Railroad testing plant at St. Louis and Altoona, and from road tests, the conclusion is reached that a horsepower can be obtained from 25 to 29 lb. of saturated steam in simple cylinders with piston speeds of 700 to 1000 ft. per minute. A fair average value has been taken as 27 lb., and in a corresponding way $23\frac{1}{2}$ lb. for compound engines, 20.8 lb. for steam superheated 200 deg. and over, and 19.7 lb. for superheated steam used in compound cylinders. These figures provide steam for auxiliaries. While careful tests show that the evaporation can be increased under the most advantageous conditions, it is considered better practice to take the lower figure in order to provide a margin for average conditions.

Pyrometer tests recently made by the Pennsylvania Railroad at Altoona with various locomotives on the testing plant showed the temperature curves of tubes of various lengths and diameter. From these curves the increase or decrease of tube evaporation may be calculated. Short tubes have much greater evaporative value per square foot of heating surface than long tubes, but they discharge the gases into the smokebox at much higher temperatures. Therefore, while the heat absorbed per foot of length is much greater for short than long tubes, it is not so economical, and the short tube boiler, other things being equal, requires more coal for a given evaporation. Where tube lengths of 12 or 14 ft. were common 14 or 15 years ago, lengths of 20, 22 and even 24 ft. are used in the modern locomotive. The result is that the smokebox temperatures have decreased from 750 to 800 deg., to 550 to 600 deg., the only increase of energy required being the slightly greater draft in the smokebox to pull the gases through the long tubes. This is not intended as a defense of the long tubes in modern engines, especially of the 4-6-2, 4-8-2, Mallet and other types, because in most cases their construction requires long boilers. Nevertheless tests show that economy results from the better utilization of heat in the modern engine than in older types because the range of temperature between the furnace and the stack is greater with the long tube locomotive.

As a result of these investigations, conclusions have been arrived at as follows:

Firebox evaporation. An evaporation of 55 lb. per sq. ft. of firebox heating surface, combustion chamber and arch tubes has been adopted. The greater absorption of heat by the firebox than by the rear portion of tubes per unit of area is largely due to radiant heat. This varies as the square of the distance from the surface of the fire to the sheets separating the gases from the water. Again it is probable that within certain limitations, the amount of heat absorbed is independent of the heating surface and is a function of the grate area or the area of the bed of live coals. Assuming that there is sufficient heating surface to absorb the radiant heat, it is probable that very little additional heat will be absorbed by increasing the firebox heating surface. It therefore follows that the relatively greater area of the fire in proportion to the absorbing surface in wide firebox locomotives is more efficient than in the old narrow firebox.

Diameter, Length and Spacing of Tubes and Flues. The evaporative value in pounds of water per square foot of outside heating surface has been approximately calculated for 2-in. and $2\frac{1}{4}$-in. tubes, and for superheater flues of $5\frac{3}{8}$ in. and $5\frac{1}{2}$ in. The range of length is 10 to 25 ft., and the spacing $\frac{9}{16}$ in. to 1 in. The best available data show that the evaporative value of a tube or flue varies considerably with differences in length, diameter and spacing. Curves of temperature compared with length have been used as a basis for determining the evaporation for different lengths of tubes and flues. The rate of evaporation on this basis will vary directly as the difference of temperature of the tube or flue gases and that of the steam contained in the boiler.

Tubes and flues from 10 to 24 ft. long, spaced $\frac{9}{16}$ in. to 1 in., outside diameter 2 in., $2\frac{1}{4}$ in. and $5\frac{1}{2}$ in., will evaporate from 7.50 to 14 lb. per sq. ft. per hour.

Grate Area. Grate area required for bituminous coal is based on the assumption that 120 lb. of coal per sq. ft. of grate per hour is a maximum figure for economical evaporation. While 200 and 225 lb. have at times been burnt in small, deep fireboxes and the engines made to produce sufficient steam, it is wasteful of fuel and it has been found after numerous and careful tests, that the evaporation per pound of coal under these conditions is very low. If the rate of combustion is too slow, economical results will not be produced owing to the fact that at least 20 per cent of the coal burned produces no useful work in hauling trains, but is consumed in firing up, waiting at roundhouses or terminals, on side tracks, or to the fact that the greater portion of the time locomotives are used at considerably less than their maximum power.

For hard coal the grates should be proportioned for a range of from 55 to 70 lb. of coal per sq. ft. per hour, according to the grade of the fuel.

Complete tables of horsepower for saturated and superheated steam, evaporation of tubes and flues of various length, diameters and spacing, and diagrams of temperature of flue lengths have all been prepared to facilitate the calculations in determining the proportions of grate, firebox, tube and flue heating surface.

It must be remembered, however, that the boiler capacity for a locomotive, when other things are in proportion, cannot usually be made too large within the permissible limits of weight, and it can be shown by numerous tests that such increase in boiler capacity makes for considerable economy in the use of fuel and steam. For passenger service the boilers may often be made with advantage over 100 per cent.

In a general way, a boiler will have ample steam making capacity if proportioned by this method for 100 per cent,

provided the grate is sufficiently large and deep so that the rate of combustion at maximum horsepower does not exceed 120 lb. per sq. ft. of grate per hour for bituminous coal of average quality. For gas coal a smaller grate may be used, but it is better practice to use the larger grate and brick off a portion at the front end in order to obtain sufficient volume of firebox for proper combustion, because nearly all large modern engines are deficient in firebox volume.

C. D. YOUNG in discussing Mr. Cole's remarks, pointed out that some few years ago when large boilers were designed, the tendency was to make the ratio of the firebox heating surface to the total heating surface less than 6. This practice resulted in locomotives which, while efficient in evaporation, were not free steaming, as they lacked capacity unless very heavily drafted. Firebox heating surface should be at least 7 per cent of the total heating surface of the boiler. When this ratio is attained, good results will follow provided the tube heating surface has been properly proportioned. It should be realized that firebox heating surface is of comparatively greater effectiveness at mean and low rates of working than the remaining surface of the boiler. When working at high rates of evaporation, the tube surface is fully as effective as firebox surface, and for large capacity a large tube heating surface is necessary.

Beyond a certain length of tube there is too great a sacrifice of boiler capacity in the interest in economy in coal. The long tube presents a very serious resistance to the flow of the gases, and beyond a length—which appears to be about 100 internal diameters—this resistance increases without a corresponding increase in evaporation. The locomotive with a long tube is a slow steamer and a higher draft must be furnished in order to create an active fire. This rule—length of tube to be 100 times the internal diameter—has been applied to three new classes of Pennsylvania locomotives with exceedingly gratifying results; and confirms the earlier experiments made by the Pennsylvania Railroad upon this subject, as well as those made by M. A. Henry of the Paris, Lyons & Mediterranean Railroad of France.

J. T. ANTHONY in his written discussion remarked that from a furnace point of view, the principal points to be considered are grate area, flameway or volume, firing clearance and air supply. From the boiler point of view we must consider the extent and location of the heating surface.

In order to secure high efficiency, the grate area should be sufficient to keep the maximum rate of combustion below 100 lb. per sq. ft. per hour at full boiler capacity, as the losses due to imperfect combustion, cinder discharge, front end gases, radiation and unaccounted for losses increase rapidly above this rate with a corresponding decrease in boiler efficiency.

The high efficiency at lower rates of combustion is due not only to a reduction in the heat losses enumerated above, but also to the relatively large proportion of the total evaporation that takes place around the firebox. Most of the heat received by the firebox heating surface is radiated directly from the fuel bed and luminous flames, only a small amount being due to convection or direct contact. The amount of heat received by radiation depends on the area of the radiating surface and the difference in temperature between the radiating and cooling surfaces.

Flues receive their heat by convection, and the amount of heat so received, other things being equal, depends on the weight of the gases going through them. This varies with the rate of combustion, and as this rate increases the flue evaporation increases. Under the same conditions the firebox evaporation increases somewhat, due to the slightly higher temperature and increase in mass of flames, but not nearly as fast as the flue evaporation.

High firebox evaporation means high boiler efficiency, for the high heat absorption by the firebox reduces the temperature of the gases entering the flues; and for any one boiler, the temperatures of the gases entering and leaving the flues are directly proportional when reckoned above steam temperature. Hence a lower temperature of entering gases means lower front end temperatures and an increase in efficiency.

A large percentage of the bituminous coal burns above the grate as gas. The rapidity and completeness of the combustion of these gases depend on the amount of oxygen present and the thoroughness of the mixing. In a firebox with 60 sq. ft. of grate, with a rate of combustion of 60 lb. of coal per sq. ft. of grate per hour, an air supply of 20 lb. per lb. of coal and an average firebox temperature of 2000 deg., the volume of the gases evolved is about 1200 cu. ft. per second. A firebox of this size would have a cubic capacity of about 200 ft., and would have to discharge and be refilled with gases about 6 times per second. The average time available for combustion of each particle of gas would be insufficient for complete and proper mixing by diffusion. With the short time allowed, it is necessary to mix the gases by mechanical means, and this is generally accomplished by an arch or baffle which forces the gases through a restricted area, this area being not less than the net flue area.

Mere firebox volume is not sufficient of itself. It is necessary to have a flameway of such cross-section and length as to mix the gases intimately and provide sufficient space for burning before gases reach flues. In an ordinary firebox, without baffle or combustion chamber, the average length of flameway is only 5 or 6 ft. By the introduction of baffles and combustion chambers, this length can be increased from 10 to 15 ft., which results in not only more complete combustion but also in increased radiating surface, with a corresponding increase in firebox evaporation and a lowering in temperature of the escaping gases.

High efficiency is obtained at low rates of combustion in spite of the large air excess. The firebox absorbs a larger percentage of the heat evolved, and the amount so received depends primarily on the temperature of the fuel bed. It is possible that this temperature is higher with large air excess.

Firebox evaporation depends primarily upon the extent and temperature of the radiating surfaces and not on the extent of the heating surface. Increasing the firebox heating surface without increasing the grate area or flameway will result in very little increase in evaporation. An evaporation of 60 lb. of water per sq. ft. of firebox heating surface requires a difference of less than 100 deg. between the water and the fire side of the sheet. If sufficiently high firebox temperatures or radiating surfaces could be

obtained, it would be possible to increase this high rate of evaporation without forcing the heating surface to its capacity.

In the Coatesville tests, the two fireboxes gave an evaporation as high as 58 lb. of water per sq. ft. of heating surface. There was practically no difference in the total evaporation by each of the fireboxes when working at the same rate of combustion and with the same grate area. One of the fireboxes had 12 per cent more heating surface than the other.

Unless the fuel is materially changed, we are not likely in the near future to see any radical departures from the present type of firebox. Any improvement in the firebox efficiency will be obtained by paying particular attention to and making ample provision for grate area, firing clearance, gas mixing, flameway or combustion chamber space, and air supply.

H. B. MacFarland offered a written discussion in which he called attention to the amount of experimental work that has been done to determine the most efficient arrangement of drafting appliances, and yet it has been often and thoroughly demonstrated that the best arrangement for a front end for any given locomotive can only be determined after careful tests in service.

Pioneer work in this country in establishing scientifically the fundamental principles of front end action was done in the locomotive testing laboratory of Purdue University. The rapid development of powerful locomotives in the past few years calls for such an increase in the boiler capacity that it was questioned whether these recommendations were still applicable to the newer types of power. In order to demonstrate the best type of drafting, the Pennsylvania Railroad recently made a series of front end tests. Definite results and recommendations were obtained only after a very well worked out series of tests with a large number of different front end arrangements. From results obtained, however, they were not able to establish recommendations governing a proper design of front end appliances which may be generally applied to all classes of locomotives, so that such an arrangement has to be left to individual tests for each class.

That the present practice of locomotive drafting is accomplished at the expense of back pressure acting against pistons has been generally understood for a long time. Although generally understood that back pressure exists in all locomotives, the magnitude of the power loss due to this back pressure has not been generally recognized.

Since draft is a function of the front end arrangement in general and of the exhaust tip in particular, it naturally follows that the operation of the high powered locomotive boilers of the present day is at the expense of a very pronounced back pressure due to restricted tip. This is particularly true when the locomotives are operated at such rates of power as to force boilers to their maximum. Data were collected from tests conducted upon 18 different locomotives representing as many different types and working under such varied conditions as are encountered upon the Sante Fé System. These data show that for every 100 h.p. used as actual tractive power, there are 66 h.p. wasted through the exhaust, over 70 per cent of which may be credited to the excessive back pressure necessary to produce draft for the locomotive boiler.

The total capacity of a locomotive boiler has been greatly increased during the past 10 years by the development of auxiliary apparatus such as superheater, brick arch, feedwater heater, stoker and other labor saving devices. An increase in boiler capacity has also been accomplished indirectly by improving the efficiency of the locomotive through improvements made in the valve gear, cylinder design, properly designed steam passages, etc. With all the developments and improvements, however, the fact remains that the determining factor in increased boiler capacity is, under the present arrangement, increased draft, and it follows that the most efficient method of producing this draft should be given serious consideration.

During complete tests made in the summer of 1914 of four different Prairie type locomotives, experiments were made to determine the effect of changes in front end arrangement. In each instance a number of runs were first made with the front end, as far as possible, in accordance with recommendations of the American Railway Master Mechanics' Association. Changes were then made in the front end arrangement to make each locomotive conform generally to the latest recommendations of the Pennsylvania Railroad. Assuming an efficiency of 100 per cent for the original arrangement, the tests show that a draft of 6 in. in the front end was produced with the new arrangement at a saving of 34.5 per cent in back pressure produced in the cylinders.

These tests show what may be accomplished by changes in front end arrangement, but when it is considered that the efficiency of the front end is very low from a thermodynamic standpoint, these gains in efficiency have very little effect on the total efficiency of the locomotive.

The power performance curves for one of the locomotives tested show that its maximum power was reached at a speed of 35 miles per hour; the locomotive developing 1350 i.h.p. and having 190 back-pressure h.p. There was a gain of 35 per cent in front end efficiency with the new front end arrangement. This means that the same draft was produced with a reduction of 35 per cent in back pressure, or at a saving of 66 h.p. This results in an increase of but 5 per cent in the capacity of the locomotive.

Curves taken from tests on a 2-8-8-2 Mallet show that maximum power was developed at a speed of approximately 17 miles per hour and that drawbar horsepower and back-pressure horsepower equalized at a speed of approximately 25 miles per hour. At this speed the locomotive exerted 950 drawbar h.p. and an equal amount was required to draft the boiler.

These tests have forcibly demonstrated the inefficiency of the present arrangement when viewed from a thermodynamic standpoint. The chief advantage of the present arrangement is mechanical efficiency; that is, it is free from any complicated parts and requires only minor adjustments. It is this feature alone that has enabled the present front end to exist to the present day.

In view of existing conditions, attention was attracted to the possibility of drafting by some method of forced or induced draft. Because of the impractibility of installing a system of forced draft, this form was abandoned. Induced draft has been successfully applied in stationary and marine service. The development of the steam turbine and progress in theory and construction of centrifugal fans make it seem logical that if the system could be so success-

fully applied to other fields it would find ready application to the locomotive. When the problem was presented to the manufacturers, they were able to calculate the size of the fan and the horsepower necessary to drive it to burn the required amount of coal. But when the space that such an apparatus would occupy was taken into consideration, they were unable to furnish either data or apparatus to meet the requirements satisfactorily. For this reason it was absolutely necessary to start in at the beginning and to develop such an apparatus.

After many experiments the MacFarland fan draft was developed. The diaphragm, nozzle pot, netting and other draft appliances were removed, leaving the front end clear for the reception of the turbo-fan unit. The smokebox proper was divided into two compartments by means of a sheet iron, air-tight partition, which made connection between the intake opening in the fan casing and the inner ring of the smokebox arch. The compartment next to the front tube was thus made separate and constituted the front end proper, the only opening being directly into the inlet of a high-speed direct-connected, centrifugal fan. The remaining compartment acted as a general housing for the fan and its operating power unit. Cylinder exhaust was led directly to the atmosphere by means of pipes leading from the front heads of the steam chest to a common stack located just ahead of the fan exhaust stack on top of the boiler. When the locomotive was working, the steam for the turbine was taken directly from the superheater; when the main throttle was closed the turbine was supplied through the blower line. While the fan used during this experiment was not mechanically correct or of sufficient capacity to develop the maximum power of the locomotive, it brought out many valuable points relative to the general performance to be expected from a system of this kind.

The experience gained led to the design of a larger fan unit which was applied to a New York Central switcher and a comparative test was made before and after installation. This installation was never satisfactory from a mechanical standpoint, because the unit employed was not adapted to the size of the smokebox on this particular locomotive. The tests further demonstrated, however, the possibilities of this form of draft for locomotives and justified the following conclusions:

(*a*) That the engine could be successfully drafted with the MacFarland fan draft. A maximum of 9 in. of draft was developed in the front end with an average of $8\frac{1}{4}$ in. throughout one of the test runs, and the fan operated successfully against depths of fire ranging from 6 to 18 in.

(*b*) That the exhaust could be muffled to any desired point by the introduction of proper netting stages.

(*c*) That the engine could be operated practically smokeless.

(*d*) That the engine burned a uniform and intense fire.

(*e*) That full operating steam pressure was readily maintained.

(*f*) That the back pressure on the engine was entirely eliminated.

(*g*) That it was not necessary to use the exhaust steam for drafting the engine.

These tests have furnished data for the design of a special unit to overcome the mechanical difficulties which have been brought out. The experience gained has also led to the development of an automatic control system to govern the speed of the turbine and consequently regulate the intensity of the draft.

C. E. Chambers remarked that he had used long and short stacks, rectangular and oblique, single and double, but thought that the single type would give satisfaction if other things were right. The height of the exhaust pipe should be not more than one-quarter to one-third.

Front end diaphragm arrangement has a lot to do with an engine freeing itself. It must be kept 6 to 9 in. away from the sheet to give a clearance.

Many railroads have trouble from smokebox fronts overheating. This difficulty can be eliminated by placing the liner about 4 or 5 in. away from the door and filling with asbestos.

C. D. Young gave statements based on facts developed by observation of locomotives on the testing plant at Altoona. These tests, during the last 10 years, embrace 23 passenger and 17 freight locomotives.

General use of the Schmidt type of superheater has had an influence in effecting a certain uniformity in the arrangement of the smokebox. The one-piece lift-pipe, connected directly to the outside of the stack, forms a very desirable and simple arrangement. Requiring only a short exhaust column, the advantage of a long stack may be obtained. A petticoat pipe, with its adjustable features, is not so desirable as the internal single-lift pipe. These adjustable features are a source of annoyance in that people not properly qualified are continually tampering with the arrangement, which results in an improper draft. It is most desirable that the gases have a free passage through the smokebox, and all possible restrictions between the tube sheet and stack should be carefully investigated as to their areas. Care should be taken to provide a passage through the superheater damper, which is at least equal to the area of the boiler and superheater tube outlets above the damper.

On railroads where there is practically little or no drifting, there would seem to be no requirement for a superheater damper. However, where a moderate amount of drifting is done, or where the locomotives are interchanged between divisions with few and moderate grades and divisions with heavy grades requiring a large amount of drifting, the automatic damper is a most essential feature for the protection of the superheater elements.

There has been a tendency of late to use exhaust nozzles having other than circular openings. The plain circular nozzle forms a steam jet which is too nearly cylindrical, or the shape of the stack, and the use of such a shape as the rectangular appear to break up the continuity or form of the jet and cause it to draw out a larger volume of gases. Both rectangular nozzles and nozzles of the dumb-bell shape have been used to success and with an increase in evaporation over that of the circular form. There has recently been developed on our testing plant a nozzle having four internal projections which appears to be more satisfactory than some of the irregular forms. With nozzles having other than a circular outlet, an increase in the evaporative capacity of the boiler of from 15 to 25 per cent has been obtained. In recent tests upon a large Pacific type, a nozzle with four internal projections has given a

maximum capacity in equivalent evaporation, from and at 212 deg., of 87,414 lb. per hour. This is an evaporation of 18 lb. of water per sq. ft. of heating surface per hour. With this capacity, an i.h.p. of 3184 was obtained. This same locomotive with a circular nozzle developed a maximum equivalent evaporation of 62,719 lb. of water per hour, resulting in an i.h.p. of 2501. No other change, other than in the exhaust tip, was made in the locomotive. The back pressure in both cases was practically identical.

Mr. Young also called attention to ashpan design as to air openings. He remarked that the air openings into the ashpan should be at least 15 per cent of the area of the grate. When the openings are of this size, the ashpan vacuum will be considerably less than one inch of water at the maximum evaporative rates.

This ratio has been found to be too large for the requirements of some switching engines. By installing ashpan dampers along the air inlets at the mud ring, this difficulty has been overcome. If the air inlets, in the ashpans of locomotives which stand around a large part of the time, are not reduced, it would be difficult for the fireman to prevent a large amount of steam from escaping from the safety valve.

H. B. Oatley in presenting a written discussion on superheating stated that the locomotive boiler presented many limitations that have an important bearing on the design and construction of the superheater. The development of the locomotive, within certain fixed clearances, has been dependent upon the size of the boiler. As the boiler increased, wheels have been added to obtain proper weight distribution. Consequently, the boiler is no larger than is absolutely necessary and in the majority of cases it is insufficient in evaporating surface.

The application of a superheater to this boiler necessitates a reduction of about 15 or 20 per cent in the tube heating surface. Furthermore, a certain percentage of the gases, which formerly was available for evaporation of the water, must now be used for superheating the steam.

Taking this boiler with its deficiencies, the superheater has produced an economy of 25 per cent in fuel as a direct result of saving 33½ per cent of the total water evaporated per unit of power. As a result of this fuel economy, greater capacity of the locomotive has resulted.

If cylinder tractive power in per cent is plotted against piston speed, it will be seen that the average modern superheated steam locomotive, using between 200 and 250 deg. of superheat, has a greater available tractive power. This is due to the fact that a longer cut-off is possible with the superheater engine at comparative speeds. The limiting factor at the usual speeds is the ability of the boiler to furnish steam.

These results have been accomplished in the face of boiler limitations, parts of the locomotive being not adaptable to the use of highly superheated steam, and lack of experience in the organization which must handle the locomotive. The problems incident to these conditions are rapidly being worked out, and results shown by the superheated steam curve will soon be as basic as the saturated steam curve was a few years ago. The future holds a possibility for further saving by increasing the degree of superheat. For some time past large passenger locomotives have been operated very successfully with steam chest temperatures between 750 and 800 deg. This corresponds to 350 to 400 deg. of superheat.

The superheater engineer has only made use of the same variety of flue sizes as was used by the locomotive designer for tube sizes. If the superheater designer should be permitted the use of a size different from the two present standards, it would be possible to obtain in a superheater boiler, evaporating surface practically as great as in the saturated steam boiler. In this case the superheating surface would be a distinct net gain to the heat absorbing surface of the boiler. With a boiler and superheater thus arranged, greater capacity may reasonably be expected.

C. D. Young remarked that it is now known that the economy due to superheating increases almost directly with the degree of superheat; and the usual type of fire-tube superheater produces its maximum superheat only when it is forced to the limit of boiler capacity.

This condition is not altogether desirable as the maximum economy should be obtained when the locomotive is working under moderate or average conditions and at an economical cut-off. A superheater that would give a uniform superheat under all conditions of working would apparently produce ideal results.

If our materials, in valves, cylinders and packing, as well as the lubrication, will withstand a certain high degree of superheat, there is no reason why we should not furnish this degree of superheat regardless of the boiler rate in order to effect the greatest economy in steam. With the usual Schmidt superheater we have observed steam temperatures as high as 670 deg., corresponding to a superheat of 291 deg. at a steam chest pressure which was 180 lb., while the boiler pressure was 206 lb. With these conditions the steam rate per horsepower hour was 19.3 lb., the speed 47 miles per hour, and the cut-off 50 per cent. With this superheat and cut-off at 25 per cent, it is reasonable to suppose that a water-rate approximating 15 lb. could be obtained. For this reason the desirability in future designs of superheaters is to produce, if it is possible, a superheater that will give us a uniform superheat regardless of the evaporation of the boiler. Until such a superheater has been produced the maximum economy and capacity from the boiler cannot be obtained under all working conditions.

C. J. Mellin presented a written discussion on compounding and in commenting on the course of progress in steam engineering, he said it was but natural that the compound engine, which had been so successfully introduced into marine and stationary service, should find its way to the locomotive.

Difference in conditions under which the locomotive operates as compared with the marine and stationary engines, in that its greatest resistance is in starting, was not fully realized in earlier attempts to introduce the compound into railway service. Various means were later employed to compensate for this difference, but for many years the compound was looked upon with suspicion.

Very little improvement, however, was made in the simple engine until the compound commenced to show its superiority by hauling heavier freight trains with the same weight on drivers as the simple engine and with a considerable reduction in fuel and water consumption, reduction in boiler repairs, improvement in smooth riding qualities, and the

practical elimination of jerks in starting, thus making a saving in car and draft gear repairs.

To compete with these advantages the simple engine was enlarged both in boiler and cylinder capacity, necessitating an increase in weight, and for a number of years the contest for supremacy was on, ending only when the limit of the right of way stopped the further enlargement of the low-pressure cylinder of the cross-compound engine; the permissible diameter being 36 in., or an equivalent to a 21-in. simple engine. The Vauclain four-cylinder compound, the four-cylinder balanced compound and the tandem compound followed, but all soon found their limitations.

The three-cylinder compound would have been the natural successor to the cross-compound but for the complications involved in applying the central main rod across the main axle, as was necessary on other than four coupled engines. Its introduction was, therefore, deferred indefinitely. Nevertheless, various designs of this type have been worked out to the equivalent of a 26-in. simple engine.

Instead of entering on this complication, a step still further in advance was taken about 12 or 13 years ago, when, after close investigation as to the best means of employing two low-pressure cylinders, the Mallet method of articulation was selected. The first design was made during the summer of 1902, retaining the American Locomotive Company's compounding system and American methods of construction throughout.

Up to this time there were few engines with higher tractive power than 40,000 lb. The bold idea of stepping up to 72,000 tractive power in compound gear and 86,000 in emergency was severely criticized. After long and serious consideration the Baltimore and Ohio Railroad decided to have an engine built to these proportions. Hardly had the engine started in regular service when its real qualities were discovered and its performance viewed with surprise. Reports of the result obtained caused personal investigations to be made by railway officials and resulted in a decided reversal of an unfavorable opinion to that of recognition of its advantages. At present 115,000 lb. in tractive power in compound and 138,000 lb. in emergency are being produced in very successful service and plans are worked out, ready when required, for engines of this type giving 140,000 lb. tractive power in compound and 168,000 lb. emergency power.

The next step for heavy power, where road conditions permit, is triple articulation, using the tender as the third unit. One engine of this type has been built having 160,000 lb. tractive power, but as yet it may be considered as experimental. On account of the limited boiler capacity on such engines, it may be necessary to make the tender engine independent of the other two units, subject to regulation at will, in order to get the maximum amount of steam for fanning the fire. The exhaust from the tender engine has very little effect by the time it reaches the stack and may therefore be carried direct from engine to atmosphere. Mechanical draft could probably be applied to advantage as a further means of increasing the boiler capacity at the slow speeds at which such an engine would naturally operate. By this means a tractive power of over 200,000 lb. could be obtained.

In the meantime the superheater has proved to be of great advantage in compounding. Practically all the superheat in the steam can be used before its final exhaust, and condensation during the latter part of its extended expansion is eliminated. This combination of compounding and superheating, when proper cylinder proportions have been observed, affords the greatest economy in locomotive operation.

Mechanical stokers have made possible the further enlargement of engines. It is also probable that mechanical draft in combination with a feedwater heater, will be an additional feature in the direction of economy, because of the possibility of running the boiler to its required capacity regardless of the speed of the engine. It also removes the unavoidable loss of power caused by back pressure in the cylinders, which loss increases with the size of the engine.

H. H. Vaughan, in discussing feedwater heating, called attention to the experiments that are being made with exhaust steam heaters, and waste gas heaters on the front end by Mr. Travithic on the Egyptian Railways. With the waste gas heater he has been able to put the water into the boiler at 250 deg. and obtain 22 per cent economy.

On the Canadian Pacific, experiments with open heaters in a tank have given fairly good satisfaction. We also applied exhaust-steam injectors to some engines and got fair results, but found that to operate them satisfactorily we should have an exhaust nozzle. We have since been advised by the manufacturers that our troubles were because of our having applied too large size an injector. While exhaust steam injectors work fairly well under certain conditions, yet there would be difficulties where the amount of water consumed would be large.

Experiments on an open heater showed that the temperature obtained from the exhaust-steam was due to the exhaust-steam from the feed pump. A temperature of 200 deg. in the feedwater is the equivalent of 160 deg. when water is put into the boiler by an injector with 100 per cent efficiency. By heating the water at the injection suction to 120 deg., we got 6 per cent economy using injectors, which we thought preferable to 10 or 12 per cent using a pump. Lately we have experimented with an ordinary closed feedwater heater.

Feedwater heating is a subject which railroad people on this side have neglected. It has the advantage of not only saving coal but increasing the capacity of the boiler, as the temperature of the water in the boiler would not be materially changed. My feeling about the heater is that we will see it coming into larger use not only with exhaust steam but with waste gas.

J. P. Neff in speaking on firebrick arches and circulating supporting tubes stated that about ten years ago very few railroads were consistently using brick arches. A number of roads were tolerating them in a very small percentage of their engines, and a large number had discarded them entirely.

As the locomotive itself has been greatly improved during the last ten years, so has this particular device. It has been shorn of many of its original faults, leaving its never disputed virtues standing out all the more prominently.

Briefly, the arch insures more nearly complete combustion. The combustion of high volatile coal at the rapid rates necessary to meet the demands for large hauling capacity, is fraught with considerable losses due to incompleteness. That represented by the CO content in front end gases is only a part. Losses from incomplete combustion of hydro-carbons may easily be four times that represented by the CO per cent in the gas analysis. Anything that will mitigate

these losses without introducing too high air excess reflects at once in higher furnace temperatures. Combustion chambers help by lengthening the flame travel, but the arch, especially the arch on water tubes, not only doubles the average length of the flame travel, but in addition possesses the more important virtue of a mechanical mixer.

By enhancing combustion over the fuel bed, considerable more heat is involved and higher firebox temperatures result. Authentic tests have shown that with certain coals this increase in temperature may be 15 per cent. As a rule, these higher firebox temperatures are not accompanied with higher front end temperatures. Thus the double result of creating more heat and causing it to be absorbed, is accomplished.

Circulating tubes or arch pipes not only present the most effective heat transmitting surface, but the circulating effect is very important, especially at high rates of combustion. As the particles of gases must quickly touch the heat absorbing surface and give way instantly to other particles, so must the water on the opposite side of these surfaces, if a high rate of heat transfer is to be accomplished. Expedited circulation will insure this favorable condition. A locomotive boiler cannot give high duty per square foot of surface when the gases move leisurely.

Arch tubes, as they are now, give much aid, but there is still more to be done in this direction. Arch tubes or circulating water tubes through the firebox may be used in still greater number with good results, if properly arranged and disposed so as to aid in mixing mechanically and in circulating without too quickly lowering the temperature of gases.

G. W. Rink in reading a written discussion on valve gear and cylinders said that while every effort is being made to increase the efficiency of the boiler, it appears that the economical distribution of steam in the cylinders has also received some attention. In general, however, we are not getting the good results such as are obtained in good stationary engine practice. This is due to long steam ports and the use of a single slide or piston valve which has to control admission, cut-off, release and compression.

A design of cylinder overcoming these objections has been introduced in recent years and is known as the Hobart-Allfree cylinder. A comparative test was made on the Jersey Central with an engine fitted with this type of cylinder and slide valves as against another engine fitted with the regulation cylinder and slide valve. These tests showed an economy in fuel and water consumption of approximately 12 per cent. Tests conducted on other railroads with Mallet engines equipped with the same style of cylinder and slide valve showed, with practically the same amount of coal per ton mile, an increase of $13\frac{1}{2}$ per cent in tonnage hauled with an increase in speed of 4.3 per cent and a saving of water per ton mile of 11.1 per cent.

Valve gears have received a great amount of attention in recent years and a design which has apparently met with considerable success is known as the Baker valve gear. This gear was designed with a view of replacing the old inside link motion. It has also been applied in preference to the Walschaert gear in many instances owing to objections due to links or sliding blocks. The Baker gear has all bearings provided with pins and bushings which are more readily inspected and repaired.

W. E. Woodard discussed detail design to secure reduced weight of reciprocating parts and other parts. He stated that in all designs it is necessary to get as large a boiler as possible, consistent with the proper design of the other parts of the locomotive. This leaves a certain amount of weight, in many cases, to be taken out of other parts, with the result that the designer scans all points where he can safely make a reduction.

In one case a systematic study of a design was made. As a result we found that 2500 lb. could be taken out without impairing the efficiency of the details or of the locomotive as a whole.

Cast steel cylinders offer a possible means of weight reduction, although they have not been used to any considerable extent. For large size locomotives, they would probably reduce the weight of the cylinders 3500 lb. per pair. There are a number of details, such as sand boxes, boiler fronts, etc., where material reductions can be made. We have been able to do much in the way of steel shakes for sand boxes. Wood cabs and wooden running boards can be used but there is a greater desirability in using steel.

Another thing is the question of changing steel worked out standards owing to new devices. I have under consideration the question of reducing the size of the cab. We have been able to reduce them from 84 in. and 90 in. down to 6 feet. The Pennsylvania has started on this line and we may see quite a little done in this way in the future.

H. V. Wille in discussing use of high-grade alloy steels to reduce weight brought out the fact that many railroad metallurgists do not consider that the possibilities of high-grade carbon steel have been utilized to the fullest extent by designers. This is no doubt due to the fact that designers and metallurgists view the properties of steel from entirely different points. The metallurgist wishes a steel of great ductility with a good elongation and reduction of area, or in other words, a steel that will readily flow under limiting loads; whereas the designer desires a stiff steel, one of high elastic ratio or a steel that will not readily flow under loads above the elastic limit. The metallurgist therefore specifies a steel with a high elongation and reduction of area and to meet these conditions the manufacturer is compelled to use a steel of medium carbon.

As for possibilities of improvements, a decided reduction in weight as well as the elimination of failures would result from a modification of existing specifications for forgings for the purpose of permitting the use of steel of high tensile strength and elastic limit even at a sacrifice of ductility as measured by the elongation and reduction of area. These views are sustained by the results of an elaborate series of tests conducted by the United States Government at the Watertown Arsenal by Jas. E. Howard, on the endurance of rotating shafts. Enormous increase in endurance following the use of material having high elastic limit and tensile strength was notable and it was shown that carbon steel shaft exhibits as much endurance as 5.6 per cent nickel steel.

When steel forgings were first proposed for use in locomotives, a soft grade of steel was generally employed, the purpose being to secure a steel of similar properties to iron formerly employed.

The use of this material resulted in an unusual number of failures of axles, pins and rods. After studying these failures, Dr. C. B. Dudley, S. M. Vauclain and S. T. Wellman experimented with higher carbon steels. This led to the general adoption of steel of 80,000 tens. str. for locomotive work, with the result that the failures were eliminated and the great superiority of this steel over the softer steels was demonstrated notwithstanding the great difference between the two steels in elongation and contraction of area. This grade of steel is still being universally employed and any changes were for the purpose of increasing the ductility requirements rather than the tensile requirements, thus handicapping the manufacturer in the development of this grade of steel.

If specifications were revised to permit the use of a 0.65 carbon steel there would be but little necessity to employ the expensive alloy steels.

C. D. YOUNG in discussing the above subject called attention to the ordinary annealed carbon steel as used generally for locomotive forgings. The minimum physical properties may be considered as follows: tensile strength, 80,000 lb. per sq. in.; elastic limit, ½ the tensile strength; elongation in 2 in., 22 per cent; reduction of area, 30 per cent.

With properly quenched and tempered carbon steel we may expect an increase in the elastic limit of 30 per cent or more, the elongation remaining the same and the reduction of area increasing about 15 per cent. These are conservative figures and a great deal better elastic limit and tensile strength may be obtained, depending upon the chemical composition of the steel and the heat treatment.

From alloy steels, such as chrome vanadium or chrome nickel, we may expect to obtain the following physical properties after heat treatment: tensile strength, 95,000 lb. per sq. in.; elastic limit, 75,000 lb. per sq. in.; elongation in 2 in., 20 per cent; reduction of area, 50 per cent.

On an average, these alloy steels will show an increase in physical properties over those of annealed carbon steel of 20 per cent or more in tensile strength, 80 per cent or more in elastic limit, with elongation in 2 in. about 9 or 10 per cent less than that of the carbon steel, and the reduction of area of 75 per cent or more greater. These figures are subject to modification on account of variation in the chemical composition of the steel and the heat treatment.

In carbon steel castings approximately the same per cent increases in physical properties as were given for carbon steel forgings may be obtained after proper heat treatment. The experience with alloy steel castings has been too limited to furnish any satisfactory data. Up to the present time the majority of users of heat treated steels seem to have made but little, if any, use of the increased physical properties as determining the fiber stresses used in design, though some of the larger builders of locomotives have made such increases in fiber stresses for both heat-treated carbon and alloy steels. In certain parts where heat treated carbon steel has been used, the fiber stress has been increased about 25 per cent above that used for annealed carbon steel, and in the case of heat-treated alloy steels an increase of as much as 50 per cent has been made. In some cases, depending upon the design and service for which the forging is intended, it is preferable to allow no increase in the fiber stress, but to consider the excess strength of the heat treated material as contributing to increased life in service, or to safety.

Recent practice has indicated that it is desirable, when using heat treated designs, to study carefully the section, so as to avoid abrupt changes, and also in the cases of larger shafts such as axles or crankpins, that they shall be hollow bored in order to provide for better treatment and to relieve shrinkage strains which occur during the quenching process.

While there is no objection to the change of the present standard section, it would seem, with our present knowledge of heat-treated material, that it would be entirely safe to use certain increases in the fiber stresses when designing locomotive parts. As a suggestion as to what could be done in this respect, I have tabled what is recommended for three grades of steel as to working fiber stresses and the minimum ultimate strength and elongation. This has been tabulated for the grades of 0.45 annealed carbon, quenched and tempered 0.52 carbon and quenched and tempered alloy steels.

The results shown in this table seem to indicate that heat-treated carbon and alloy steels will show greater resistance to wear and to the fatigue stresses in service than are shown by annealed carbon steel; and it is our opinion that the increase in resistance to wear is about in proportion to the increase in Brinell hardness which is brought about by the heat treatment.

C. F. STREET in a written discussion stated that stokers have not only increased the earning power of existing locomotives but have also removed all limitations, from a fuel quantity standpoint, on the size of locomotives which can be built.

Many instances could be cited of the increase in earning power of existing locomotives. Take the case of a saturated steam locomotive having about 54,000 tractive power and a tonnage rating over a certain division of 4750 tons. Superheaters were applied and the tonnage rating increased to 5000 tons. Stokers were applied and the tonnage rating increased to 5250, then 5500, then 5750 and finally to 6000 tons. In the meantime, the tonnage rating of the shovel-fired superheater locomotive increased to 5500 tons. The increase in the tonnage rating of the shovel-fired locomotives is very interesting and brings out strongly one of the indirect advantages of the stoker. It shows very clearly that before stokers were applied the shovel-fired locomotives were not doing anywhere near what they should do, and as soon as the stoker came into use, it increased the earning power not only of locomotives to which it had been applied but to all others on the division.

Reference to several of the locomotives mentioned in the committee's report brings out the fact that the stoker has removed limitations on the size of locomotives. The mountain types referred to were fitted with stokers when they were built and have always been stoker-fired. A number of other locomotives, notably the most powerful Pacific type as yet built, are now in regular operation and would never have been contemplated without a stoker. As high as 8 tons per hour have been put in a firebox with an existing machine and without working it to capacity. There is no reason why any desired quantity of coal cannot be fired by the use of a stoker and this limitation is entirely removed in connection with the designing of new locomotives.

The stoker, as yet, has not progressed far enough

to bring forth definite figures regarding its efficiency. Wherever it has been introduced the question of increased tonnage has been more important than that of fuel economy. This is only a temporary condition and as more stokers are applied the question of fuel economy will become more important. We have, however, gone far enough to determine definitely two points: First, the stoker will burn a much cheaper grade of coal than it is possible to use with hand firing; second, it will give a more uniform rate of fuel consumption on locomotives performing the same service.

It is a well-known fact that there is a difference of from 25 to 50 per cent in the amount of coal burned by different firemen for performing the same work. The stoker is eliminating this great variation and making the results more uniform.

There are today very few shovel-fired locomotives in this country having a maximum tractive power of 50,000 lb., or over, which are being worked to their full capacity. Wherever stokers have been applied the earning power of the locomotives has been increased from 10 to 20 per cent. There is no instance where stoker-fired and shovel-fired locomotives are being operated under identical conditions. The stoker-fired locomotives are in every case, hauling increased tonnage, using a cheaper fuel or working at higher speeds.

E. A. AVERILL remarked that in a report of a test on a large locomotive at the Altoona test plant it is stated that the results indicate that the capacity of the boiler was limited by the ability to burn the coal on the grates and not by any failure of the heating surface to absorb the heat supplied. While in this case the limit was marked by the impossibility of supplying sufficient air through the grates to burn the fuel properly, there are a reasonably large number of locomotives operating in this country today which are running at less than full boiler capacity because of the physical inability of the fireman to supply the amount of fuel that can be burned.

He said he had selected at random 10 classes of locomotives built during the past three years which are typical of the general size and capacity of all the larger freight locomotives built in that time. When delivering the power that each of these locomotives is easily capable of, if in good condition, it was seen that they required from 4900 to over 8000 lb. of good quality coal an hour. They are actually getting from 4500 to 5000 lb. an hour, and handling trains of a proportional size.

A number of locomotives like these, all of the same class, and operating on the same division, will have a tonnage rating in proportion to the ability of the average poorest fireman that is assigned to them rather than to the average best fireman. While there may be a few firemen on the division who are capable of developing the full boiler capacity, the group of engines as a whole may be daily working much below their actual capacity.

The acceptance of the opportunity to supply the desired quantity of coal at all times to these locomotives that is offered by the stoker, will have the same practical effect on operating expense as would a new order of more efficient, larger locomotives.

A reduction in the cost of conducting transportation follows this increased locomotive capacity in a number of the principal items when presented on a ton-mile basis. The stoker itself offers an opportunity for further savings particularly in the cost of fuel, reduced claims for damage or accident and the recruiting of men of higher calibre for locomotive service.

An instance of the possible savings in the cost of conducting transportation, through increased locomotive capacity following the application of a stoker, is found on a certain division where 10 tonnage trains are sent one way over the road each day with hand-fired locomotives. Application of stokers has permitted an increase of over 11 per cent in the tonnage of a train. The return movement is largely empties. The application of stokers will give a direct saving from wages and train supplies alone, of about $100 per engine a month on this division. If advantage is taken of the increased capacity of the division for tonnage without the addition of more locomotives, the saving will be considerably larger.

Naturally one of the first features to be investigated by a railroad considering the application of stokers, is the cost of maintenance. In general, the machine of any kind with the fewest parts, if they are properly designed, will cost the least for maintenance, inspection or repairs. During the past year and a half there has been a distinct advance made in connection with the simplification of the stoker apparatus. The latest type of locomotive stoker consists of a comparatively few, strong, heavy parts and a very few wearing surfaces.

There has been much discussion of the amount of coal consumed on stoker fired locomotives. In some cases they do burn more coal per trip and the mistake of making the comparison on pounds of coal consumed per 1000 ton miles has led to the deception of some investigators. Accurate tests permitting the comparison of shovel and stoker firing to be made on the basis of pounds of coal per indicated horsepower, have shown widely varying results with different designs of stokers. Some carefully conducted evaporative tests with the most recent design of stoker are very encouraging in this particular. These tests were made with the locomotive in regular service. Comparing the average of five hand-fired runs and four stoker-fired runs on the basis of actual pounds of water evaporated per 1,000,000 B.t.u. supplied, the stoker gave an increase of nearly $7\frac{1}{2}$ per cent. In another case the increase in evaporation with the stoker was nearly 12 per cent. From these figures, as well as observations in regular daily service, it would appear that some saving in coal can be expected from this stoker. These tests were made with run-of-mine coal.

A stoker should successfully handle the coal in any condition in which it may be put on the tender. It should make no difference if it be all dust or clean lumps of larger size; soaking wet, slightly damp or bone dry. It should take the coal as it finds it the same as a fireman does. The development of stokers in this direction during the past year or two has been particularly satisfactory and ordinary run-of-mine coal is now being used with complete success.

The use of lower and cheaper grades of coal is quite general on the stoker locomotives of a number of roads which report a net saving from the practice.

Calculations that have been made of the movement of the gases in a firebox equipped with a brick arch, show that velocities of 265 ft. a second will be present over the end of the arch when burning 6000 lb. of coal an hour on 70 sq. ft. of grate area. The velocity decreases as the fire bed

is approached and at a point 2 ft. above the grate the gases have an average velocity of about 33 ft. a second. This clearly indicates the importance of injecting the fuel charge as low down in the firebox as possible to reduce the loss by fine coal passing through the flues partially burned. The more recent development in stokers has given this feature the attention it deserves.

Opportunities for economy in connection with the reduction in damage claims follow the better lookout from the locomotive by the fireman being left free to watch signals, crossings and operation of the machinery on the left side. One of the essentials in this connection is noiseless operation. The stoker should not prevent free conversation across the cab nor make any noise that can be heard when the locomotive is running. The development of the past year or two has shown a wonderful improvement in this particular and stokers are now being applied which are essentially noiseless in their operation.

The stoker should be 100 per cent efficient; it should do all the firing, handle all the coal from the tender with the minimum attention and not require alteration of the distributing means after it is once properly adjusted. The fireman should be free to attend to the duties mentioned above and should be able to control the stoker operation from a position on the seat box.

It is well established in manual firing that small quantities of coal fed frequently and distributed by the "cross fire" method gives the most perfect combustion. The stoker should follow this method but perform the operation more exactly than it can be done by hand.

Another feature of improvement in the most recent of the scatter type stokers is the absence of any part of the stoker on the boiler head or in the cab. Stokers are now being applied which show practically nothing in the cab and thus allow the best arrangement of the many instruments and appliances required on a modern locomotive. This also permits the proper inspection of all the staybolts and their renewal if necessary without the removal of any part of the stoker.

J. E. Muhlfeld in a written discussion stated that the available energy in superheated steam, and the necessity for economy in first cost and for operation will cause the self-contained steam locomotive to remain for a long time the principal motive power for moving heavy tonnage trains long distances. For this reason, the next few years will probably see it substantially improved through the development of Mallet articulated types, superheating, compounding, feedwater heating and pumping, boiler circulation, valve motion gear, reciprocating and revolving parts, combustion, automatic stoking of pulverized fuels and standardization.

G. R. Henderson pointed out that 15 or 20 years ago it was thought that we had reached the limit of size and capacity in locomotives. Shortly afterwards we had some gain in compounding but we had large locomotives giving only from 1000 to 1500 h.p., whereas the size would have led us to think that we could get double that power.

Superheaters, coal pushers, firedoor openers, etc., have all helped to increase the capacity of the locomotive. In a few years we will very probably have largely extended the use of powdered coal. The present limitations of height and width will not differ to a marked degree but the length can be increased without any special alterations except for turn tables and things of that sort where we can easily increase the length.

Our boilers can be increased in length, and there comes in Mr. McFarland's idea of an exhaust fan at the front end to give the necessary draft in the firebox. Powdered coal will help a great deal in assisting in lengthening the firebox and giving a greater amount of evaporative surface.

If we consider the present limitations of drawbar strength, length of siding, and legislative restrictions, I think by this lengthening it is possible to build a locomotive from 250,000 to 300,000 lb. tractive power.

J. B. Ennis in a written discussion stated that 25 years ago the largest steam locomotive in service had a total weight of about 154,000 lb. and a tractive power of 34,000 lb. At that time, a locomotive of these proportions represented the improvement of 60 years of effort in this line of steam engineering, and while this advance had been gradual, it was a series of progressive steps leading up to the building of this "largest locomotive in the world." This 60 years of progress had been a period in which the main object seemed to be increased capacity only. Aside from the fact that the number of wheels was increased and the parts were made larger and heavier, a locomotive of this period in its essential details followed closely the established practice of years before. Detail design had been constantly improving, but at that time no general effort had been made toward improvement in the efficiency of the machine. A pound of drawbar pull meant the burning of the same amount of coal as it had a quarter of a century before.

During the past 25 years conditions have materially changed and the demands made on the locomotive have been such that the progress in its development was to be rapid. From 1889 to 1899 the total weight increased from 154,000 lb. to 232,000 lb. and the power in proportion. It was during this period that it was first realized that increase in capacity could not go on so rapidly unless accompanied by some efforts toward economy. The first general step in this direction was the introduction of the compound principle. Various systems were brought out and for years large numbers of these engines were built, many of which gave decided economies in service as well as increase in power. Although the movement to adopt this principle was advocated by many, the simple locomotive was still preferred and gradually increased in weight and power until it was thought by many that the limit of capacity had been reached.

Fifteen years ago, we find instances of locomotives built, where in order to maintain full power for any length of time, the amount of coal burned was so large as to call for considerable activity on the part of the fireman. Perhaps fortunately, stoker designs had not been perfected, although the time could not have been greatly delayed when consideration was to be given to other devices to bring about efficiency.

In Europe, superheating had demonstrated its economies in locomotive service and about ten years ago the first applications were made in this country. For some time its use was very limited, but after it was proven that high temperature superheaters would give increased capacity and great economy in fuel that would not be offset by high

maintenance expense, and that the economy could be obtained in all classes of service, the movement to adopt this principle became widespread. As a result of this improvement, combined with others that followed, we now have passenger and freight locomotives giving at least one-third more power at the drawbar than would have been possible 10 years ago with simple locomotives using saturated steam and consuming the same amount of fuel.

This increase in weight and power continued and the locomotive soon reached a size where it became necessary to consider, in many cases, some other means of feeding the coal than by hand. The mechanical locomotive stoker was demanded and produced. It is no longer an experiment and is capable of delivering all of the coal that the present day locomotive requires.

As examples of the big steam locomotives of to-day, we have simple freight locomotives giving tractive powers 50,000 lb. greater than the maximum of 25 years ago; an experimental articulated locomotive for pushing service designed to give a tractive power of 160,000 lb; articulated locomotives for road or pushing service with tractive powers of 115,000 lb.; the simple pacific type with 46,500 lb. and simple mountain type with 58,000 lb. Individual wheel loads have steadily increased until we have nearly 70,000 lb. weight per pair of drivers. Our locomotives are as high and as wide as clearance limitations will permit, and yet it would be unwise to say that the limit has been reached.

The big steam locomotive of the future will probably not be the locomotive of the past. To-day we can see possibilities toward further refinement in design; further economies that may be obtained so that the locomotive designer is not yet ready to acknowledge that all has been accomplished.

For freight and pushing service on heavy grade, past performances show the adaptability of the articulated compound engine. This design of locomotive is still in the course of development and it will, without doubt, be the generally accepted type for these conditions for some time to come. With the exception of the experimental articulated locomotive already referred to, locomotives recently built for the Virginian Railway are the largest of the type. A few particulars of their performance may be of interest. Designed originally for pushing service on grades of over 2 per cent and normally rated at 115,000 lb. working compound, these engines have proven themselves capable of handling on a grade of 0.6 per cent a train load of 7180 tons, requiring a drawbar pull of approximately 110,000 lb. On lighter grades and at higher speeds over 3000 i.h.p. have been obtained. Work of this magnitude necessitates locomotives of exceptional weight and power, and yet the possibilities of this type have by no means been exhausted. As conditions arise in the future in which more power will be required, the use of the articulated engine can yet be extended.

For freight service on easy grades where the capacity of the articulated engine is not required, we already have exceptionally large locomotives of the 6, 8 and 10 coupled types. Simple cylinders operating at 200 lb. pressure have reached a diameter of 30 in., and in order to transmit this power a main axle 13 in. in diameter has been used. Main crankpins, rods and other details are of enormous size. With the increase in the diameter of cylinders, the cylinder centers have gradually increased and frame centers decreased. This has resulted in higher stresses of parts than those caused by piston thrust only. The weight of revolving and reciprocating parts has reached the point where, in some cases, proper counterbalancing becomes very difficult. It is doubtful whether much more capacity can be obtained in these types if designed along the present lines, and here it would seem that attention could profitably be given to refinement in design and its relation to the careful selection of materials.

Modern passenger locomotives have reached a high development, and yet there is one problem still to be solved that has been recognized for many years—that of the effect on the rail of the vertical unbalanced forces in a two-cylinder engine. At present our largest and most powerful passenger locomotives have two simple cylinders 27 to 29 in. in diameter, giving maximum piston thrusts of approximately 117,000 lb., with static wheel loads higher than ever before and, with few exceptions, reciprocating parts of much greater weight.

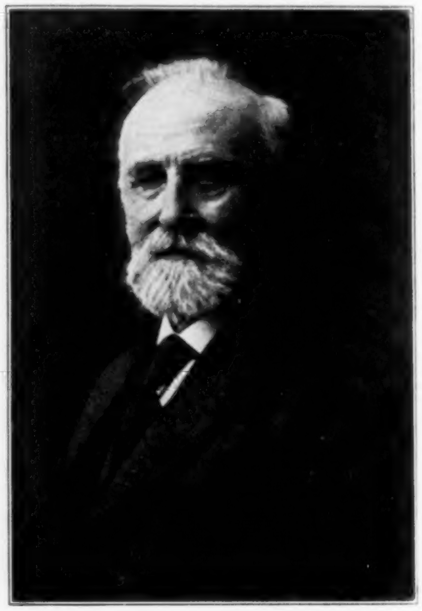
The four-cylinder balanced compound was introduced about 10 years ago as a possible solution and for a few years a large number of these locomotives were built. There is no doubt as to the results obtained, as far as balancing was concerned, and yet recently very few have been constructed. Four-cylinder simple locomotives have also been tried out, but in both these types the capacity is limited on account of the available space between the frames, making it practically impossible to provide the power now given by the largest simple two-cylinder engines.

Little consideration has been given to the advantages of the three-cylinder arrangement, although a few locomotives of this type are in successful service today. As compared with the four-cylinder engine, either simple or compound, the three-cylinder type offers, first, the possibility of increased power. With one cylinder located between the frames ample room is provided for a properly designed crank axle and main rod which cannot be arranged for in the four-cylinder type beyond a certain limit. As compared with the two-cylinder engine, the advantages are briefly, a more even turning moment, an ideal counterbalancing condition and the opportunity to furnish maximum power with the minimum destructive effect on the rail. The power obtained in a two-cylinder engine with cylinders 27 in. in diameter and a maximum piston thrust of 117,000 lb. can be obtained in a three-cylinder engine with cylinders 22 in. in diameter and a maximum piston thrust of 78,000 lb. This decrease of 33 per cent in thrust means a corresponding reduction in the individual weights of all of the machinery, particularly the weights of reciprocating parts.

It is true that much progress can yet be made in the two-cylinder engine towards reducing the weights of reciprocating parts by the careful selection of materials and proper design. The three-cylinder engine, however, offers advantages possessed by no other arrangement, and it would seem that for high-speed passenger service, at least, this type is well worth considering for the future.

JOHN FRITZ MEDAL AWARD

ON Wednesday evening, December 2, the John Fritz Medal Board of Award conferred the John Fritz Medal for Notable Scientific or Industrial Achievement upon Prof. John E. Sweet "for his achievements in machine design and pioneer work in applying sound engineering principles to the construction and developing of the high-speed steam engine."



JOHN E. SWEET, RECIPIENT OF THE JOHN FRITZ MEDAL

Very happily this event was arranged to occur during the Annual Meeting of the Society. The exercises were signally successful and thoroughly enjoyed. There was a large audience and a number of distinguished members of the four great national engineering societies were seated on the platform. Gano Dunn, president of the John Fritz Medal Board of Award, acted as presiding officer.

JOHN EDSON SWEET

Dr. Sweet's prominence as a national figure dates from his connection with the Sibley College of Mechanic Arts of Cornell University, in 1873. His connection with this institution lasted only until 1879, and in that brief period he rose from a position of obscurity to one of prominence, which he has ever since maintained. It was a case of the man and the hour. Mechanical engineering as a department of organized education was a new thing. In it there were no precedents, and regarding it there was almost universal skepticism. Its plans, its scope and its aims were unformed even among its friends, and its friends were few. Those who should have been its friends were largely doubters of its practicability, while among educators of the scholastic type it found no sympathy and less support. In its field there were, of necessity, no experienced educators, and perhaps it was best that there were none. The field was fallow, and into it came, almost by accident, the personality of this untried and unknown man.

His work was two-fold; first, that of a teacher, and second, of a pioneer in mechanical construction. As a teacher, the immediate results of his work will necessarily die with his students, but as a pioneer he laid enduring foundations. Previous experience in England had shown him the fundamental importance of the work of Whitworth, which, because of our then happy-go-lucky methods, had found little appreciation on this side of the Atlantic. Combining an appreciation of Whitworth's advanced standards of accuracy with original conceptions of fundamentally correct principles of construction of a kind far surpassing Whitworth's work, he established a school of construction of which the influence has been far-reaching. Along with this went an application of art in design—not the art of ornamentation, but the highest of all, and in engineering work the only true art, that of perfect adaptation to purpose—that has never been surpassed and probably never equalled. The Straight Line Engine was an embodiment of these principles, and from all points of view a perfect illustration of them.

Analysis of a successful teacher's methods is always difficult, and the greater the success the greater the difficulty. There is, perhaps, no field of human endeavor in which individuality has greater scope, as there is certainly none in which the methods of different, though equally successful, men differ more widely. Of Professor Sweet's methods there was little organization and less formality. For their prototype we must go back to the schools of the Greek philosophers, who gathered their students about them and taught by a process which was one of absorption rather than acquisition. Without compulsion, students gravitated to him as pieces of iron to a magnet. With few material aids and resources, and in that wider sense which consists of the training of the faculties and the formation of correct methods of thought and work, no finer example of educational work can be found. Those who came under its influence felt, and still feel, that they enjoyed a precious privilege. As a teacher, Professor Sweet was one of those few and rare, whose pupils became disciples, and to his success there is testimony that is unique—the informal organization of men, most of them beyond the meridian of life, who, calling themselves Professor Sweet's Boys, gather year by year on the occasion of his birthday, and from long distances, for an annual dinner with him at Syracuse. If any similar tribute is paid to another teacher the fact is not known.

Dr. Sweet was born October 21, 1832, at Pompey, N. Y., his mechanical talent being an inheritance through his mother. His introduction to mechanical

work was through his apprenticeship to the carpenter's trade, from which he developed as a builder and architect. In 1862 he went to Europe and for a time worked in England as a mechanical draftsman. Returning in 1864, the peculiar individuality of his work soon began to manifest itself, his most ambitious production of this period being a type-setting machine which is still preserved at Cornell University. Later, he was engaged in bridge building for Howard Soule, from which work he was drafted to the Cornell shop, where his pioneer work in accurate measurements was done. This with other examples of student workmanship was exhibited at the Centennial Exposition, where it attracted world-wide attention. The Straight Line Engine Company, with which his name has been identified, was organized soon after leaving the University. It was his suggestion which led to the organization of The American Society of Mechanical Engineers, of which he was the third President, nominations for previous years having been declined in favor of others whom he—mistakenly and characteristically—considered better fitted for the office. Other honors have been showered upon him, and always, as in the present case, against his protest. The most unselfish and helpful of men, and completely devoid of the spirit of self-seeking, he has found his reward in the unstinted esteem of his fellow men.

THE EXERCISES OF PRESENTATION

In his opening remarks Mr. Dunn said that the meeting was not so much in honor of Dr. Sweet as in recognition of the things which Dr. Sweet himself has done, which alone can justly do him honor. He then introduced the first speaker of the evening, Dr. James Douglas, past-president of the American Institute of Mining Engineers, who gave an address on the Development of Engineering in the United States.

ADDRESS OF DR. DOUGLAS

Dr. Douglas spoke particularly of the work of the engineer in the mining industry. The miner has always been more or less of an engineer. The primitive engineer was ingenious, and could install his own hoist and pump and if he had a running stream used the force of falling water to generate power and even compress air. With the introduction of the steam engine, however, came the need of the assistance of the engineer. For three-quarters of a century a very simple type of engine served the purpose; but within the memory of most of us there have followed in quick succession engines of elaborate design to economize steam, railroads, telegraphs and telephone, the dynamo, and electricity, applied to manifold uses. Each branch of engineering required a skilled expert in its application to mining and the engineering staff is now a distinct complement of the mining and metallurgic members of every large organization in this field and are accepted as essential helpmates.

The engineering members of the modern mining and smelting plant outnumber those who direct the primary operations of the enterprise. On the roll of the Copper Queen Company, for instance, omitting the administrative and accounting officers, there are at headquarters a consulting engineer, with several expert mechanical and electrical assistants and draftsmen. Apart from them the mining staff consists of a superintendent, an assistant superintendent, a geologist and three assistants, three chemists, an operating electrician and 10 assistants, a chief mechanical engineer and 13 assistants.

In the smelting department of the same company, apart from the furnace superintendent, his assistant and two understudies, the officers are a mechanical engineer, an electrician and 12 assistants, a chemist and physicist and five chemists engaged in purely experimental work.

At both the mine and the smelter the power is generated in central works distributed by compressed air or electricity to hoist at surface, and underground; to power drills; to trolley lines; light circuits; to all of which more or less expert skill must be directed.

The power utilized at the mines is derived from 411,623,120 cu. ft. of compressed air and 321,539 kw-hr. The power generated at the Douglas Smelting Works is 3339.4 h.p. In mining, therefore, the amount of engineering supervision is out of all proportion to the quantity of power generated.

If we look beyond the metallurgy of the more costly metals whose value is in proportion to their scarcity, the demands upon the skill and energy of the engineer rises rapidly. On the average 83 tons of iron are consumed for one ton of copper, and when one traces the iron from the mine through the monstrously large smelting and rolling mills, where the metallurgist is almost obscured by the engineer, over the railroads to the stupendous buildings, where the iron is to be buried in concrete and brick to the amount of 10,000 to 30,000 tons per structure, one appreciates how intimate must be the alliance between the engineer and the miner and metallurgist.

Dr. Douglas referred to the metallurgical element in mining and metallurgical work. He came to the conclusion that the last person to select in this capacity is the expert, for if he is a trained mechanical engineer, mechanical devices will be too attractive; or if an electrical engineer, he will be emphatically an electrician, and so on. The manager should have instead just as much and as little knowledge of each branch as will enable him to select competent men and decide when a proposition is laid before him, presenting alternative methods, whose argument is most conclusive.

In respect to the future, in the light of the con-

servation of our resources, the speaker said that although it is not very difficult to estimate the date of the exhaustion of our ores at the present proportionate rate of increase, we nevertheless appear to be more worried about the consumption of our forests, which can be restored, than over the almost reckless consumption of iron, which rusts and vanishes. On the other hand, in respect to coal, we may be confident that long before the supply is exhausted, power, heat and light, and all that coal confers upon mankind will be derived from the transformation of other natural forces through the accomplishments of the physicists and the engineers, and that humanity will be relieved from the grimy work of delving underground for fuel.

ADDRESS BY DR. STRATTON

Following Dr. Douglas, Dr. W. S. Stratton, Director of the Bureau of Standards, Washington, D. C., addressed the meeting on The Relation of Standards to the Development of Engineering.

He said that no greater tribute can be paid the honored guest of the evening than to say that he was a member of the small group of men who, in laying the foundation of modern engineering practice, introduced into it precision measurements. They made possible and introduced the interchangeable system of manufacturing, one of the principal factors in our country's industrial development.

For precision measurements are required certain standards which belong to the general group of Standards of Measurement. Other groups of standards may be roughly classed as Standard Values of Constants; Standards of Quality; Standards of Mechanical Performance; and perhaps Standards of Shape and Form. The government is interested in each of these but for widely different reasons. In some cases, principally standards of measurement, it is from the standpoint of authority vested in it by the Constitution and absolutely necessary for the sake of uniformity in the measurements upon which all other forms of standardization depend. In other cases, it is interested in the standards and measurements used in the collection of duties and revenues, in the development and conservation of our natural resources, in the promotion of commerce and industry, and in placing its own work on an economical and business-like basis. To care for these interests, Congress established the Bureau of Standards in 1901. The Bureau does not assume an authoritative position except as to standards of measurement; in the other cases, its capacity is that of assistance in their establishment and advisory as to their use.

Standard values of constants enter into physical quantities, and are used in every branch of scientific work or industry. The amount of heat required to change a pound of water into steam under normal conditions, and the relation between heat and mechanical energy, are two important physical constants; their values are used in practically every computation in connection with the designing of steam engines and boilers, the tests of their efficiencies or the measurements of their output. The amount of heat required to turn liquid ammonia into vapor or the amount required to melt a pound of ice are constants equally important in the refrigerating industries.

THE JOHN FRITZ MEDAL IS A DISTINCTION FOR NOTABLE SCIENTIFIC OR INDUSTRIAL ACHIEVEMENT CONFERRED FROM TIME TO TIME IN MEMORY OF THE GREAT ENGINEERING PIONEER, JOHN FRITZ, AND THE AWARD OF THE MEDAL IS MADE BY A PERMANENT BOARD OF AWARD COMPOSED OF FOUR DISTINGUISHED MEMBERS FROM EACH OF THE FOUR GREAT NATIONAL ENGINEERING SOCIETIES

No one institution can accomplish more than a small part of the experimental work in this field. It is being done in government laboratories and scientific institutions throughout the world, hence the government is interested not only in the production of such data, but in gathering them together from all sources and in making them quickly available to the public as well as acting in an advisory capacity as to their use.

In considering standards of quality, it may be found

that a certain kind of steel, a cement, a paint, an oil, or a paper or cloth, is found by use to be good or poor. The questions then arise, what are the physical or chemical properties, or the particular combination of elements which make it of good or poor quality; how are its properties to be measured or its constituents determined. These are questions for the laboratory to answer and again involve scientific investigations of the most difficult sort.

The government is interested in this class of standards, partly from selfish motives in connection with its own purchases and construction, but principally from the broad standpoint of the public interest generally, just as it is interested in increasing the productiveness of the soil or in developing our mineral resources. The economical and proper use of materials is an exceedingly important factor in the great problem of their conservation.

The actual testing of materials by the government through its Bureau of Standards, to ascertain whether or not they comply with specifications, is confined almost exclusively to government purchases, but in making these tests, in which the Bureau has had the hearty coöperation of practically all the departments of the government service, it is compelled to make many investigations concerning the properties of materials, their specification and measurement. While this work is of great value in placing government purchases on a correct basis, the results of the investigations as to the properties of materials and the information gained in testing government supplies, is even more important to the general public.

In respect to standards of performance, the performance of an engine or boiler, a pump, an electrical generator or motor, a weighing device, or a telescope, can usually be measured, but the quantities to be measured and the method used must be specified correctly, and understood by all concerned in the construction, purchase, or use of such apparatus. To do this properly involves the use of standards of measurement, standard values of constants, and standards of quality. The Bureau of Standards does not attempt to cover this field completely, but only those cases where there is a lack of definite scientific data upon which to base specifications, and to the more important classes of apparatus.

Again, the Bureau's activities in this field have been principally in connection with government purchases of apparatus and machinery. Government purchases of equipment, however, are not greatly different from those of the public. Whenever the Bureau makes a scientific investigation or secures such information from other sources for the purpose of the improvement of specifications, it is given to the public in the form of suitable publications. The value of this from the standpoint of the public is even greater than that in connection with government purchases, important as the latter is. In other words, the needs of the public and the government service are precisely the same as far as standards or specifications are concerned, whether it be standards of measurement, quality or performance.

Many questions of disagreement between public officials and utility companies as to standards are referred to the Bureau for advice or adjustment. There is a great need for unbiased and reliable information pertaining to the standards entering into the regulation and sale of the services of public utilities. A striking illustration is to be found in the various state regulations pertaining to locomotive headlights. Some regulations require that headlights shall not be less than 1500 candlepower when measured without a reflector; others specify 10,000 candlepower measured with a reflector. Some states require 300 watts at the arc, while others require that an object the size of a man shall be distinctly seen at a specified distance (they do not state the color of the object), and one state specifies the size of the reflector. There are plenty of such cases.

Some of these regulations are almost as absurd as the law proposed by a Western legislator to make the ratio between the circumference and diameter of a circle the whole number three; or another who, when told that the law of supply and demand interfered with some proposition in which he was interested, introduced a resolution repealing that law.

The Bureau's investigations in connection with the distribution of high potential electric currents, the mitigation of electrolysis, the fire-resisting properties of materials, the standards involved in the regulation of gas service, and the causes of failure of railway materials, are all examples of investigations that are being carried on by the Bureau with a view to ascertaining the fundamental facts needed in making public utility regulation sensible and fair. No doubt the question has already arisen in your minds as to whether this work competes or interferes with that of the engineer; on the contrary, these investigations are for the purpose of ascertaining the very information the engineer needs. The Bureau prefers to work through the engineer. Whenever it comes in direct contact with public officials in such matters, the Bureau encourages the employment of competent engineering services. There are many cases in which it would be far better for those concerned to employ more technical and less legal advice. The Bureau's coöperation with engineers and manufacturers is another important phase of its work.

The value of such minute measurings is sometimes questioned, but they are necessary for the detection of laws or measure constants, which will make it possible to make accurate measurements with even the accuracy required in industrial processes. In the past three or four years one of the Bureau's experts has been engaged in perfecting the instruments used in measuring total radiation, in order that he might determine

among other things the radiation constants with sufficient accuracy for use in the industrial measurement of high temperatures. Recently one of these instruments was used successfully at the Lick Observatory to measure the radiation from stars as faint as the seventh magnitude, or, in popular terms, equivalent to the detection of the radiation from a candle flame fifty miles away.

PRESENTATION ADDRESS

John R. Freeman then spoke on behalf of the Board of Award. He touched in his remarks on the life of John Fritz, saying that he left the art of iron making better than he found it and furnished an example which must be an inspiration to all. The John Fritz Medal was founded on Mr. Fritz's eightieth birthday. The principal rules for its award, as adopted, are that it shall be given for notable scientific or industrial achievement, after consideration by the Board of Award for one year. The Board itself is composed of sixteen members, chosen in equal numbers from the four national engineering societies, the American Society of Civil Engineers, the American Institute of Mining Engineers, The American Society of Mechanical Engineers, and the American Institute of Electrical Engineers.

Eight awards of the medal have been made: in 1905 to Lord Kelvin; in 1906 to George Westinghouse; in 1907 to Alexander Graham Bell; in 1908 to Thomas A. Edison; in 1909 to Charles T. Porter; in 1910 to Alfred Noble; in 1911 to Sir William H. White; in 1912 to Robert W. Hunt.

Mr. Freeman concluded his remarks with the following tribute to John E. Sweet:

To-night the medal is to be bestowed upon the one who more than any other one man now living brought about the forming of The American Society of Mechanical Engineers—to one who years ago as a college professor quickened the life and human interest of many men now no longer young—to one who pioneered in high-speed steam engine building and taught the necessity of precision of workmanship and of opposing stress with metal placed directly along the line of force, if one would double or treble the work to be performed per pound of metal.

Like John Fritz he comes to our meetings as Holmes said, "not 82 years old but 82 years young." His presence brings to mind the words of the poet of Abou Ben Adhem, who begged of the recording angel to at least "Write me as one who loves his fellow men," and who later saw

"The Angel writing in the book of gold
The names of those whom love of God had blest,
And lo, Ben Adhem's name led all the rest."

We bestow the medal upon one whose life has been lighted by a sweet and kindly ideality. Engineering, dealing with hard structural materials, by rigorous theorems, may seem to some to give small place for ideality. Kipling gives a glimpse of the other side, in McAndrews' Hymn.

Poets and painters have hardly excelled in ideality our great engineers working for the good of mankind: for example, Westinghouse dreaming of safer transportation and the manufacture and distribution of power for the service of man: Edison in bringing music to the humblest home; Brashear, Swasey and Warner working in their machine shops have brought the precision of machinery, by application in astronomy, to uplift the soul of man; Leland in that kindliness of heart and love of good workmanship which leads him not only to build the best he knows, and to prize good tools as pictures in steel, but also to gladly help his competitors; Taylor, not always understood, working to improve the understanding between labor and capital, by striving always to bring the workman to higher usefulness; and Hiram F. Mills devoting thirty of the best years of his life without thought of compensation, and as an act of religion, to found the profession of engineer of public health. This kind of man is also illustrated in Alexander Lyman Holley, Hoadley, Trautwine, Loammi Baldwin whose wonderful library of ninety years ago marks the idealism of the "father of Civil Engineering in America," also by Crozier, Hartness, and a hundred others whom we cannot now particularize.

And to this noble army of idealists belongs the friend whose faithful work we commemorate to-night, the manufacturer, who chiseled in stone over the doorway of his works, "Visitors always welcome."

The meeting closed with the formal presentation of the medal by Gano Dunn "to John Edson Sweet, ripe in years, ripe in honors and ripe in the respect and affection of the whole engineering profession."

DISCUSSION OF THE BOILER REPORT

The importance of the problem that has arisen in the formulation of the report of the Boiler Specifications Committee was again emphasized by the attention that was given to the discussion of the Progress Report (fourth printing) that was issued by the Committee before the Annual Meeting. The report was brought up for discussion at the regular business meeting of the Society at the Wednesday morning session, December 2, and monopolized the remainder of that session until adjournment at 1 p.m. The discussion was adjourned to a separate session in the afternoon and after that to an evening session. On the next day the discussion was continued all day, and was concluded with a five-hour session on Friday, December 4, making a total of six separate sessions, aggregating 20 hours of continuous meeting devoted exclusively to the discussion of the Boiler Code and the work of the Boiler Committee.

At the first session, the business meeting of Wednesday morning, the report of the Committee was brought up in open meeting in accordance with the regular procedure of the Society of discussing all important matters in preliminary form before their final presentation. John A. Stevens, Chairman of the Boiler Specifications Committee, opened the subject by a short address. He called attention briefly to the need for the Boiler Code which the Committee is at work upon and outlined the development of the work up to the present time and the methods that had been provided for all who had further suggestions or criticism of the report. He urged them to submit any suggestions to the Committee at this meeting and in that way to coöperate in facilitating the production of the final report—a matter of the greatest urgency at the present time in view of the need for a definite code which will permit the standardization of boiler work in all parts of the country.

In opening the discussion the President ruled that consideration should be given to the details of the Construction Code only, each subject involved and each paragraph to be taken up serially throughout the book, wherever discussion might be offered. This ruling brought objections from some members, however, and contrary to the proposed procedure, the President entertained a discussion of the general considerations of the report as a whole. A limited amount of unfavorable criticism was made by some who raised objections to the method of procedure carried out by the Committee and by others who objected to the general proposition involved in the Committee's work in so far as it involves proposal of legislation. Considerable discussion followed this, in which the great majority favored the general plan and commended the Committee in its work. Several attempts were made to resume the proposed plan of discussion of the report paragraph by paragraph, but there was no concerted effort made to do this until after a motion to discuss the report as a whole, was voted upon. This gave those who were not in sympathy with the purpose of the Committee's work an opportunity to express their opinions and a vigorous argument as to the merits of the form of code proposed, its effect upon the boiler industry, its advisability and desirability, etc., followed. Finally, a strong attempt was made to bring a motion before the meeting that would test out the points of advisability of continuation of the Committee's work, but the motion was curbed by numerous amendments and was finally delayed by the adournment for the noon recess.

The meeting reconvened at 2 p.m., at which H. G. Stott, Vice-President of the Society, presided. The motion that was before the meeting before it adjourned was withdrawn, and the discussion of the Progress Report began as had at first been planned. It began with page 27 and was continued with careful detailed attention to each paragraph. The criticisms ranged from minor points of punctuation or grammatical arrangement to questions of correctness of the rulings, consistency of the various requirements, and other items of engineering significance. For example, the safety valve requirements which had been approved at a conference of safety valve manufacturers in coöperation with the Boiler Committee and had been considered an important advance in this direction, were not well received by practical men; they were strongly criticized by those who had had actual experience in inspecting boilers, on the ground that they were too complicated and cumbersome for convenient use and also because the method of basing the steam producing capacity on the heating value of the coal would in certain cases require larger safety valves to be applied if boilers were to be moved to states where different fuels would be encountered. The criticism on the modified requirements of this section was so strong that it was decided to refer the entire problem back to the safety valve conference, at which the requirements were proposed.

The remainder of Part I of the Rules for Construction were passed through with a fair rate of progress, detailed attention being given to such questions as fusible plugs, steam and feed piping connections, water column connections, etc., but the argument on the validity of the Tables of Joint Efficiencies was delayed until later. The second session was then concluded with a discussion of Paragraphs 84 and 85 on page 188, relating to the question of welded joints in shells. This resulted in suggestions for slight modifications in wording.

The third session, Wednesday evening, began with a general discussion of the material specifications that

comprised pages 189 to 212 of Part II. Efforts have been made to bring these specifications into complete harmony with those of the American Society for Testing Materials. It appears, however, that the specifications in their present form, are acceptable to that Society, but where there are minor differences present, it is not unlikely that modifications may be made in the American Society of Testing Materials specifications so that they will agree with this group in all particulars.

It was shown, however, that the group of specifications in the Progress Report should be amplified by the addition of further specifications to cover iron rivets, staybolt steel and bar iron and bar steel. This matter was referred to the committee representatives of the steel manufacturers, with instructions to select specifications from the American Society of Testing Materials standards which would cover these requirements. Considerable discussion ensued relative to the form which these specifications should take and the proposed modifications, but no definite action was taken. The new tube specification which was the result of the first complete conference of boiler tube manufacturers in America was favorably commented upon.

The material requirements of the Code were then discussed and extended consideration was given to the matter of the quality of boiler steel specified for the various portions of boilers. This important part of the Code was discussed here more thoroughly than it had been in any other conference or hearing that had been held by the Committee. The result was a complete modification of this section and a final settlement of the question in such a manner as to satisfy entirely the various associations and interests involved. In general, the ruling now stands that furnaces, shells, combustion chambers, or any part of boilers under pressure and exposed to the products of combustion, are to be made of the firebox grade of steel. The other requirements were also revised into better form and made complete by additions to cover a number of other materials used in boiler construction.

The fourth session, on Thursday morning, was devoted to continued discussion of the Rules for Construction section, from page 215 to the end of the Code. In this section, such topics as maximum allowable pressure, efficiency of ligament, staying of heads, dished heads, staybolts and other subjects of kindred importance were considered in great detail, and in the course of the discussion, many minor differences were brought up and argued to satisfactory conclusions. Among these was the case of the lap seam for boilers, which, while manifestly unsuitable for power boilers, was amply strong and offered unmistakable advantages for heating boilers. The result of this discussion was the suggestion that the requirements for heating boilers be segregated in a section entirely distinct from the power boiler rules, so that the particular requirements of this class of boilers can be adequately treated. This matter was referred to a representative committee of heating boiler manufacturers for further study.

The various requirements that tended to limit the sizes of boilers or to enforce unnecessary hardships on manufacturers, received careful attention. The lengths of plates permitted in horizontal return tubular boilers, and the question of lap joints on domes, were decided upon with slight modifications. These were of decided advantage to the manufacturers of small boilers. The clause limiting the length of longitudinal joints was stricken out and that referring to the process of forming butt straps radically modified. Some discussion was given to forms of expression, used in connection with this section of the rules, and many suggestions were made to obviate the possibility of ambiguity in the various rules.

In the afternoon session on Thursday, a variation in procedure was admitted for the convenience of certain members who found it necessary to leave the city that night and who wished to discuss the Recommendations on page 255. Arguments were offered against Paragraph 1 on that page, for the reason that it would limit the size of horizontal return tubular boilers below what is considered by some as good practice. After an extended expression of views, a revision of this paragraph was agreed upon which seemed to relieve the difficulties, to obviate which this paragraph had been drawn.

Following this, some discussion was participated in as to the advisability of the so-called Recommendations Section of the Code, which has been omitted in the Massachusetts Code. The chairman of the Committee explained at great length the purpose and advantages of such a section, and pointed out how better practice might thus be influenced by the moral effect of such Recommendations, which would not, however, have the injurious effect of enforcing hardships upon those for whom they were not intended. As a result some further corrections were made and Paragraph 12 was shown to be of such importance as to warrant its transfer to the main body of the Rules, but no further suggestions were received.

After this, the attention of the meeting was again given to the Rules, beginning at Paragraph 150, page 224 to page 245. The subjects taken up included staybolts, staying heads of boilers and segments of heads, riveting, calking, manholes, settings, valves, feed and blow-off piping, and the provisions for non-standard and second-hand boilers. Many of these points were extensively discussed and some changes were agreed upon for the improvement of the rules in their practical application.

At the sixth and closing session, Friday morning, December 4, at which Vice-President I. E. Moultrop presided, a few points were taken up which had been passed over rather hurriedly in the previous session, particularly in connection with feed piping, point of entrance of feed water to boiler, etc. The requirement

calling for a stop cock between the check valve and the boiler proved very objectionable to some, and there was an extended debate on the question and a vote of the meeting was necessary to settle it. The question of blow-off piping was taken up again and then steam piping, water columns and their connections to the boilers, and the factors of safety of non-standard and second-hand boilers. It was voted that the questions of factor of safety and age limit be referred to a committee consisting of Prof. A. M. Greene, Jr., chairman, Prof. Wm. Kent, Frederick Sargent, F. H. Clark, Thos. E. Durban and H. G. Stott. Another action of importance was a resolution authorizing the transfer of the entire section at the back of the Progress Report referring to stays and furnaces, pages 259 to 267, to the body of the Code, starting on page 233.

The final work of the session was in connection with the matter of the advisability of retaining the tables of efficiencies of riveted joints. There was heated argument which extended to the origin of the tables, the reasons for including them, their practical value, etc. A motion was then made to the effect that a new set of tables should be prepared, using the tensile strength of 55,000 lb. only and the new revised shearing strength values for the rivets. This was put to a vote and carried. Various other details of the proposed modifications in the tables were discussed and settled by vote, and a committee was appointed to redraft the tables.

The final action of the session was the discussion of the policy of procedure in further revision of the report, in which a strong sentiment developed for the elimination of the features of laws and legislation from the report. This seemed to be necessary to bring the Code into acceptable shape for several of the bodies interested in its promulgation. A motion was made to express the sentiment of the meeting, which directed that the Code be redrafted so as to eliminate all legislative requirements and concentrate upon technical rulings and engineering features only. Before adjourning, some time was spent in consideration of the matter of the further revision, the receipt of further criticism and suggestions. The Committee made another appeal for constructive assistance which would tend to make the Code the best that could possibly be produced.

FOREIGN REVIEW AND REVIEW OF PROCEEDINGS OF ENGINEERING SOCIETIES

ENGINEERING SURVEY

With the present issue, the Engineering Survey enters into the second year of its existence in its present enlarged form, and the Editor takes this opportunity to acknowledge gratefully the many letters of kindly encouragement and useful suggestions received in this connection.

A new system of headings for the articles in the Foreign Review section has been introduced in this issue, the title of the article being prominently printed in the center of the headline, and a brief summary of the article being given in the next paragraph, so as to enable the reader to see at a glance what the article contains. The reference to the source from which the article has been abstracted, has been relegated to the end of the abstract. In view of the fact that of late numerous orders have been received for having articles which are abstracted in the Engineering Survey photographed from the originals in the files of the Library, the number of pages that would have to be paid for if ordered for reproduction, is indicated at the end of the article.

The Library of the Engineering Societies, as part of its work compiles bibliographic references on various engineering subjects. It is proposed, from time to time, to reprint such bibliographies when the abstract of an article covers a matter of sufficiently general interest on which a search is available. This month, such a search is given on the subject of waterproofing concrete.

THIS MONTH'S ARTICLES

Data on the combustion of benzole in internal combustion engines are given from an article describing the work done at the Technical High School at Karlsruhe. The next abstract describes an interesting Pelton turbine installation which is said to use the largest jet so far applied. In the same section there is a description of a water level indicator by which it is possible to discover variations as small as 0.078 in., and which can be read at a distance.

The section on Mechanics contains several abstracts of interest on the experimental determination of the uniformity of running of prime movers; flow of oil in pipes; torsion strength of reinforced concrete beams; application of the principle of Saint-Venant to the solution of problems on beams; the principle of variation in the theory of elasticity.

A description of an improved surface cooler and data on a centrifugal machine for drying sludge are found in the closing sections of the Foreign Review.

Excessively dry air in cold stores is the subject discussed by Wm. D. Sawers before the Cold Storage and Ice Association. Data on Chinese concrete, and on the difference between steel and iron reinforcing elements, hooked bars and straight bars and other data are presented in a report of a committee of the Engineering Society of China.

The application of the counter-current principle to directly fired and waste heat boilers forms the subject of the paper of George H. Gibson before the Engineers' Society of Pennsylvania. The author arrives at some interesting conclusions, on the use of economizers especially, which are at considerable variance with the view usually held.

The testing, and some particulars of construction, of a large reversible rolling mill is described by Karl Nibecker in a paper before the Engineers' Society of Western Pennsylvania. The tests have shown an inordinately large loss of power in accelerating and retarding the engine parts, but a very low loss of power due to friction, and indicates several other features of interest to the engine designer and rolling mill man.

The paper of F. A. Weymouth on typical rail failures describes various causes of rail failures, gives a classification of defects, and discusses the so-called frictionless rail. Another paper dealing with steel structures, in this case ship plates, is that of W. J. B. Wilson, where a remarkable failure of a consignment of such plates is described, and it is shown how unreliable the indication of the usual methods of investigation and testing may prove to be in some cases.

Two papers abstracted from the Journal of the Western Society of Engineers, treat of the characteristic curves of centrifugal pumps, and of permeability tests on gravel concrete.

FOREIGN REVIEW

Hydraulics

WATER TURBINES ON THE BORGNE RIVER PLANT.

The article forms part of a series describing water turbines and their governors. In particular, it describes a Pelton turbine delivered by Escher, Wyss & Co., for the Borgne River plant of the Aluminum Industry Co. of Neuhausen. It is remarkable both on account of its size and its design.

The water is delivered to the turbine by pipes 900 m. (2952 ft.) long and 1100 mm. (43.3 in.) average diameter. These pipes are lapwelded by hydrogen flame. The turbines are rated at 7500 h.p., with a maximum output of 8250 h.p. at speeds of 273 to 300 r.p.m. The exciter turbines have an output of 600 h.p. at 800 r.p.m. The turbine is shown in Fig. 1 A. It has a runner of 2.5 m. (98 in.) theoretical diameter and a *single* nozzle out of which, with needle fully withdrawn, issues a jet 0.2 m. (7.8 in.) in diameter. This is the largest jet hitherto applied. Fig. B shows the way the blades are held. Each blade is held by two staggered ring elements and supported against the next blade, so that the bolts have only the purpose of holding the segments together. The runner is made entirely of steel casting. All parts of the turbine which are subject to normal wear are installed in such a manner as to be easily and quickly exchangeable. A steel shaft is supported on two lubricated ring bearings, symmetrically disposed with respect to the center plane, while collars are provided to take up the axial thrust; each bearing has two lubricating rings and an oil circulation pump which sends back to the bearing the oil flowing away from the cooling pipes.

Fig. A indicates the needle nozzle with the needle and its appliances, jet deflector and the mechanism for moving the governor. On the same level with the turbine shaft to the left, at a distance of 2150 mm. (84.6 in.), is located the governor shaft driven by the universal oil pressure regulator. This shaft actuates the entire regulator mechanism. The

needle rod is loaded by the hydraulic pressure on the needle cylinder (220 mm. or 8.6 in. in diameter) as well as by the pressure of the spring which acts on its left, so that the resultant axial force A acts always in the direction from left to right. Opposed to this, there is a resistance which, being transmitted by a rocker arm, comes from the pressure regulator with effective cylinder diameter of 180 mm. (7.08 in.) and located 413 mm. (16.9 in.) above the needle rod. During the opening motions of the needle, this resistance is considerably smaller and the axial force is overcome by the force delivered by the servomotor.

The construction and operation of the governor is evident from Fig. C, where for simplicity's sake, the organs producing the load on the needle rod have been omitted and the servomotor is shown as if acting directly on the main rocker arm of the governor mechanism. The mechanism consists of the main rocker arm ac with a rigid axis of rotation b;

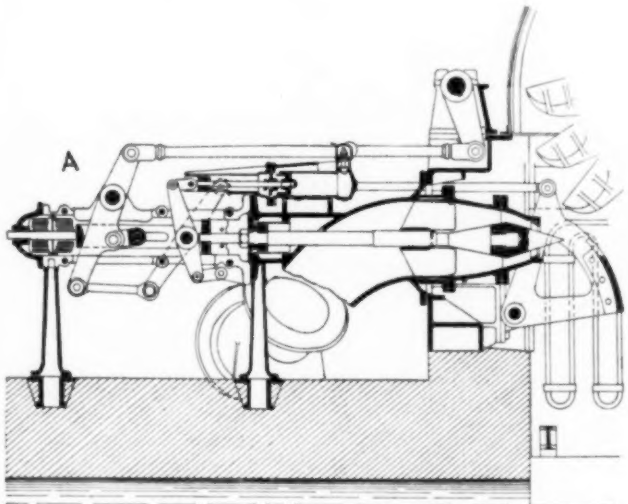


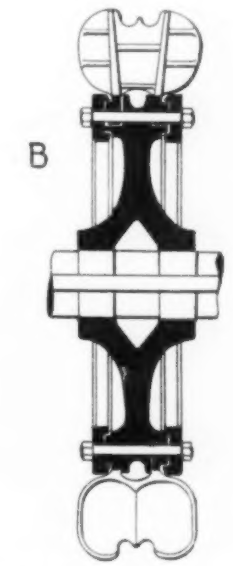
FIG. 1 LARGE PELTON TURBINE AND GOVERNOR

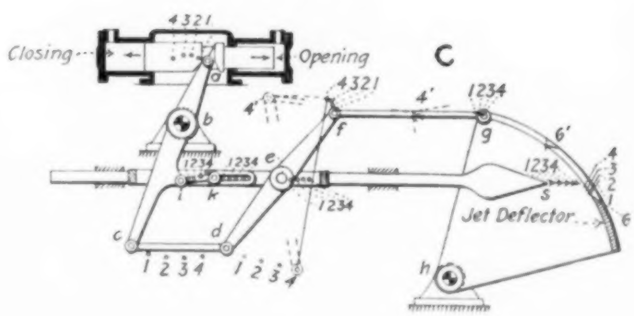
rocker arm df has its axis of rotation e located on the needle rod and controls the deflection of the support of the jet defl ctor by means of links cd and fg. The main rocker arm is connected with the needle rod by the rod ik, but the bolt k can glide in a slot in the needle rod so that the motion of the needle rod follows directly that of the main rocker arm only when the bolt k presses against the left hand end of the link. This will happen always when the pressure regulator is absent or inoperative and therefore, when the resultant axial force A acts on the needle rod. In such a case in positions 0, 1, 2, 3, 4 of the point a, the needle automatically takes the corresponding positions and at the same time the edge σ of the deflector surface takes the positions indicated by similar figures. To each position of the servomotor, there corresponds a certain position of the needle and a certain position of the deflector, their motion being simultaneous.

The purpose of the mechanism is that in case of sudden and large falling off of load, the jet deflector should be deflected so far that the jet should not strike the wheel; at the same time, the needle starts in the direction of closing the nozzle and this motion continues until the new conditions of load permit corresponding opening of the nozzle. At the same time, this motion of closing should develop with decreasing velocity in order to prevent dangerous pressure surges in the nozzle and piping. Simultaneously with that, the jet deflector should be thrown back again so far that in the normal state of operation established under the new conditions of loading, the edge σ of the jet deflector should be outside of the region of the jet, but as near to it as possible. (*Die Wasserturbinen und deren Regulatoren an der Schweizerischen Landesausstellung,* Bern 1914, Professor **Franz** Prášil, *Schweizerische Bauzeitung,* vol. 64, no. 19, p. 205, November 7, 1914, serial article, not finished. *d.*)

ELECTRIC WATER LEVEL INDICATOR WITH DISTANT READING.

A description of an electrical apparatus for reading at a distance water levels in water power plants, such as to per-





mit the observation of very small variations of level to within 2 mm. (0.078 in.). It is operated electrically.

The apparatus described, the details of which are shown in Fig. 2, has been developed by the Siemens & Halske Company, in Germany. It is usually placed in a special little house above a brick-lined shaft, care being taken that there be no turbulent motion of water in the shaft (this is attained by a proper arrangement of piping). The apparatus is provided with a copper float of about 600 mm. (23.6 in.) in diameter. From the float there extends to the indicator a wire rope passed over several rollers, and a counterweight to keep the rope tight. On the axis of the indicator are placed three toothed switch wheels, displaced with respect to each other by a one-third pitch. Each wheel operates a contact lever conductively connected with the in-

dicator apparatus. Therefore three conductors with a grounded return circuit are required, as shown in the sketch. The indicator apparatus is provided with a six-roller motor, consisting of six single-coil circularly disposed electromagnets, the pole shoes of which are directed radially inwards at angles of 60 deg. Each pair of electromagnets is connected in such a manner that the opposite pole shoes should form opposite poles while in the intervening space. There is an easily rotatable axis carrying two soft iron armatures and transmitting its motion to the indicator axis.

If the float causes the switch wheels of the apparatus to rotate, in either direction, the three contacts are moved one after another in such a manner that the next contact is always closed before the contact previously closed is thrown open. In this way, one after another, the three pairs of electromagnets of the indicator are first excited and then left free of current and the armature is forced to rotate in the same sense as the axis operated by the float. A constant current flows through the conductors with a small amperage of only about 0.035 amperes, current being provided by a special battery. Atmospheric discharges have scarcely any influence on the operation of the indicator since at all times there is a pair of electromagnets operated by the line current and the armature tends to remain in any position which it has. A further advantage in the application of open-circuit current lies in the fact that should there occur a break in the conductor or should the battery give out, an alarm circuit will be closed and will at once indicate the trouble. Should it be desired, the indicator can be equipped with a recording apparatus which will show the level of water by a curve on a drum in the usual manner. An apparatus of this type is used in the city works of Gotha, Germany. (*Elektrische Wasserstandsfernmeldeeinrichtung für Feinanzeige*, Georg Schmidt, *Zeits. für gesamte Turbinenwesen*, vol. 11, no. 29, p. 429, October 20, 1914, 3 pp., 4 figs. *d*).

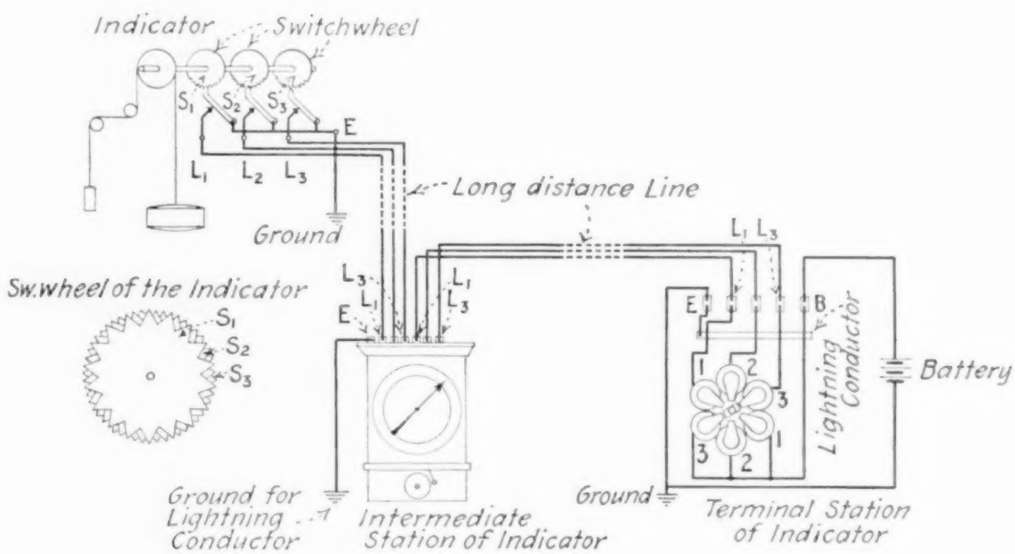


FIG. 2 WATER LEVEL INDICATOR

Internal-Combustion Engineering

COMBUSTION OF BENZOLE IN INTERNAL COMBUSTION ENGINES.

The article presents tests on the combustion of benzole in internal combustion engines and covers the matters of load compression, ignition and air supply.

The incentive to carry out this experimental investigation was given by tests on heat balance of a 3 h.p. liquid fuel Otto engine, carried out in the mechanical laboratory of the technical high school at Karlsruhe. During these tests, it was found that a fairly considerable amount of energy given to the engine could not be traced and it appeared that this heat loss could be caused only by incomplete combustion of the fuel in the motor as well as conduction and radiation. Even though the constructive part of combustion engines has been well developed and they belong to the class of engines most reliable in their operation, still a good deal remains to be found out with reference to the combustion processes in the motors. It appeared, therefore, of interest to investigate as to how far incomplete combustion contributes to the errors found in the heat balances and how they are affected by the variations in load, compression, ignition and the amount of air of combustion. Products of incomplete combustion are to be looked for in the form of combustible particles in exhaust gases in the condensing water of combustion and in soot deposits in the cylinder. The formation of soot has been very small in all of the tests carried out and its determination therefore could be neglected. The same applies to the case of combustible materials in the water of condensation. It is well-known how few investigations of exhaust gases on engines have been carried out. This may be due to the fact that a chemical investigation of special mechanical problems is too seldom undertaken.

From the investigations of Slaby and Haber, the author proceeds to a brief sketch of the work of Weber, Eugen Meyer and Brook Sewell. More recently, Häuser has determined the heat losses through the exhaust gases of a gas engine in the form of unconsumed material. He used the method of combustion over copper oxide, while Haber and Weber attempted to determine the quantitative combustion of exhaust gases. Häuser considers the method of Haber unreliable since there is not always enough oxygen in the exhaust gases to fully consume the unburned particles. All of the above investigators have found that the amount of

combustible material in the exhaust gases of gas engines does not attain very high values and so far as the influence of load can be considered, it was found that the engines work better at full load.

As regards the kind and amount of combustible particles in the exhaust gases of internal combustion engines using liquid fuel, there are no investigations with the exception of an unpublished thesis by Rudolph Mayer (Karlsruhe, 1909), who has determined volumetrically the percentage of carbon dioxide, oxygen and carbon monoxide, but his data are not claimed to be particularly reliable since his gas samples were not carefully taken average samples and the investigation of the gas was carried out as a side line.

Benzole is not adaptable for use in Diesel engines on account of its endothermic character. It can be only imperfectly changed into oil gas and its compression to the point of self-ignition involves great difficulties. As regards explosion engines, benzole, although it boils at a fairly low temperature (79 deg. cent.), and although the explosion limits of benzole vapor-air mixture are nearly the same as those of gasolene vapor-air mixture, a benzole driven motor has been developed only after considerable trouble, one of the main difficulties having been that of overcoming the tendency of benzole to form soot deposit. It was necessary therefore to investigate the combustion of benzole in engines and it is to this problem that the present experiments have been devoted.

The article describes in some detail the experimental engine and installation. The compression space of the engine could be varied by placing on the piston rod head intermediary pieces so as to increase the compression. The gasification of the benzole was effected by means of a vaporizer illustrated in the original article. It is virtually a needle gasolene vaporizer and does not present anything special in its construction. The Brauer crank mechanism was used to drive the indicator drum.

As regards the collection of exhaust gases, the first attempt was to collect them in a tank filled with water into which they were brought by suction by means of a descending water column. This method proved to be inconvenient on account of the great solubility of the gases in water. Considerable improvement was introduced by determining at the engine the percentage of carbon dioxide which forms the most soluble part of the exhaust gases. To do this, the exhaust gases were passed through two washing bottles, in which, also, the water of combustion carried with the gases was kept back. Then the gases were dried by calcium chloride and anhydrous phosphoric acid, and led into the apparatus for the determination of the carbon dioxide consisting of a Geisler sodium apparatus with KOH 1:1, as well as pipes with calcium chloride and anhydrous phosphoric acid; behind the latter were placed an unweighed protective tube filled with calcium chloride. The gas freed in this way from carbon dioxide was then collected in a gas holder provided with a thermometer, manometer, admission and exit pipes over water.

Later on this method of work, still quite complicated and liable to be a source of errors due to the solubility of gases, was simplified by the use of a mercury gasometer whereby the precision of the analysis was very much enhanced.

The author proceeds to the discussion of the method of gas investigation. Dry exhaust gases consist of carbon monoxide, carbon dioxide, hydrogen, methane or hydrocarbons, oxygen and nitrogen. The analyses made and given in table 1 correspond to three loads at maximum compression. They are, however, only of a preliminary nature. It was found that heavy hydrocarbons are but seldom met with and then only in small quantities consisting mostly of acetylene and sometimes traces of benzole. Only in the gas in a test on 10 kg load, on defective ignition, it was found that because of the defective ignition due to sooted spark plugs, an excessive amount of hydrocarbons was formed; notwithstanding the presence of free oxygen, considerable quantities of acetylene and traces of benzole remained unconsumed.

Of particular interest also, is the presence of methane in the exhaust gases of benzole fired engines. More about this will be said later. It was found, however, that volumetric analyses were not sufficiently precise for the determination of heat losses as unconsumed material in the gas. The author resorted therefore to gravimetric determination in which he could have used three ways: the fractional combustion method of Bunte-Haber-Weber; fractional combustion method over copper oxide and total combustion over copper oxide at red heat. Experiments have shown that because of the small amount of acetylene and benzole present side by side with methane in the exhaust gases, the fractional combustion method is not applicable and a total combustion method over copper oxide was used; the products of incomplete combustion in gas, freed from carbon dioxide and water vapor, were completely burned to carbon dioxide and water over copper oxide at red heat and the amounts thus produced were determined analytically. Although this method gives no information as to the constituents of the gas, it was used here because what was of interest to determine was the heat lost in the form of unconsumed material. The author shows in detail the construction of the apparatus which he used. He also calculated the limit of error and found that it was such as to be entirely negligible in comparison with the amounts of carbon dioxide and water produced.

TABLE 1 EXHAUST GAS ANALYSIS

	10 Kg. Load		10 Kg. Load, Defective Ignition	8 Kg. Load		4 Kg. Load
CO_2	12.5	8,9	6,27	12.0	8.8	8.7
CnHm	....	....	1,56	....	....	0.3
O_2	1.0	4,1	2,40	1,2	1,2	1,0
CO	4.0	6,0	10,25	7,1	10.6	11,1
H_2	1,2	2,4	2,40	2,3	4,18	5,0
CH_4	0.2	0,24	0,5	0,25	0,43	1.4
N_2	81,1	78.36	76,62	77,15	74,79	72,5

As a basis of all tests on output where a complete heat balance is used, an exact knowledge of the elementary composition and heat of combustion of the fuel must be considered. In the tests, two kinds of commercial benzole were used, and the author describes in detail the data which he obtained from the analyses. It was found that the fuel represented mixtures of various hydrocarbons with boiling points from 69 to 120 deg. cent. (156.2 to 248. deg. fahr.). He determined the upper heat limit of the gas by means of a Berthelot-Mahler bomb calorimeter and found that the

upper limit of benzole No. 1 was 9777 cal. per kg. (17598 B.t.u. per lb.) and benzole No. 2—9902 cal. per kg. (17823 B.t.u. per lb.). The article is not finished. (*Über die Verbrennung von Benzol in Explosionsmotoren,* Dr.-Ing. E. Terres, *Journal für Gasbeleuchtung,* vol. 57, nos. 39 and 40, pp. 893 and 907, September 26 and October 3, 1914, serial article, not finished. *eA*).

Mechanics

Flow of Oil Fuel in Pipes

Data on frictional resistance to flow at varying temperatures of four kinds of oil fuel in pipes of three, four, and five in. diameter.

It is taken from a report of the National Physical Laboratory through *Page's Engineering Weekly.* For the purpose of these tests, special appliances were constructed and include a centrifugal pump with adjustable speed regulation for producing the flow, weighing tanks for measuring the flow, circulating pump and coils for heating and cooling the oil to the required temperatures, and sensitive gages for measuring the fall of pressure along the pipe. In considering the method to be adopted for producing and maintaining a steady rate of flow through the pipes, it was realized that the frictional resistances to be measured were so small that the use of a plunger pump connected directly to the pipes was precluded on account of the fluctuation of pressure that would be produced. Flow under gravity from a large supply tank erected at a height above the laboratory floor sufficient to give the maximum flow required would have been the most satisfactory method, but as the expense of installing this arrangement would have been considerable, it was decided to design a special form of centrifugal pump for effecting the circulation. This was found to work quite satisfactorily, with the exception that in the case of the thickest oil tested, which had a viscosity at 15 deg. cent., which is 3,000 times that of water, circulation could not be produced at temperatures below 22 deg. cent.

As, however, the flow was streamline in character for temperatures far above this value so that the resistance could be predicted from the known values of the coefficient of viscosity, the necessity for observations at low temperatures on this oil was not of great importance, and it was decided to make the low temperature experiments in pipes of small diameter at the conclusion of the research. The pipes used for the experiments were cold drawn steel and about 140 ft. in length. The fall of pressure was taken on a length of 5 ft. situated about 45 ft. from the outlet of the pump, and was measured by a sensitive mercury tilting gage. In this way a pressure of 0.005 in. of water could be detected. (*Page's Engineering Weekly,* vol. 25, no. 530, p. 459, November 6, 1914.)

Uniformity of Running of Prime Movers and Its Experimental Determination.

Discussion of causes of lack of uniformity in the speed of rotation of prime movers; methods of its experimental determination, and description of apparatus designed for this purpose by the author.

In a paper presented to the Aix-la-Chapelle section of the Verein deutscher Ingenieure, Doctor Bonin, after indicating various causes for the lack of uniformity in the speed of rotation of prime movers, especially machinery driving ships and electric lighting generators, indicated that the construction of experimental devices for determining the uniformity of such machinery is an extremely difficult problem. A pendulum tachograph for the investigation of governing processes did not give sufficiently reliable indications as to the variations of speed during a single revolution, because the pendulum of the indicator itself might get into oscillations which affected the equilibrium of the pendulum. Riehm, in 1912, succeeded in practically limiting these natural oscillations of the pendulum by resorting to the use of an electric eddy current tachometer with an extremely small oscillating mass. Since, however, in order to maintain the oscillating mass as small as it was, he had to use a beam of light as a recording medium and make the record on a photographic plate. The apparatus is not suitable for shop use.

Tests of Mader, who attempted to determine the motion of the engine from single harmonic oscillations by means of an apparatus which he called "undograph," and also the exact law of motion of the engine from the data thus obtained, have been successful in their way, but again the process is far too complicated to be used commercially. Attempts have been made also to record the motion of an engine as a function of time, but when the small scale which can alone be used for practical purposes is employed, the deviations of the curve so obtained from the ideal straight line are so small that no reliable data as to the uniformity of motion of the engine can be secured therefrom.

In the apparatus designed by the author, the pendular paths are recorded directly. A freely rotatable and exactly balanced fly-wheel mass coupled with the engine by a moveable pawl so that it will have the same speed of rotation as the engine and also the same variations of speed is placed on a prolongation of the engine shaft. Should this mass be suddenly freed from its connection with the engine, it will run at the same speed which the engine had at the instant of uncoupling, and further, the speed of rotation of the mass will remain nearly exactly the same while the engine in its rotation will sometimes lead and at other times lag behind the mass. These motions may be recorded on a drum running at uniform speed by means of a light recording pen located between the mass and the engine, the record being such that the abscissae are times and ordinates are the relative paths of the engine with respect to the mass. From this oscillation diagram by some process of differentiation, the relative velocity of the engine with respect to the mass can be determined for each instant, and by this means also the degree of non-uniformity. The oscillation curve in the apparatus proposed is recorded by means of a steel scriber on a specially prepared sheet in such sharp lines that it can be read with great precision. The speaker found it to be so during his tests on a calibrated device and on a gas engine. (*Uber die Gleichförmigkeit des Ganges von Kraftmaschinen und ihre experimentelle Bestimmung,* paper by Dr.-Ing. Bonin before the Aix-la-Chapelle section of the Verein deutscher Ingenieure read on June 17, 1914, published in *Zeits. des Vereines deutscher Ingenieure,* vol. 58, no. 46, p. 1562, November 14, 1914, 1 p. *et.*)

The Principle of Saint-Venant and the Solution of Problems on Beams.

Application of the Saint Venant principle to the solution of problems on beams.

The abstract is translated from *Beiblätter zu den Annalen der Physik*, as the original publication where the article appeared is not available at the present time. The validity of the principle has not been proved analytically except for particular cases. The author proves it for plain deformations in a beam. The analysis refers to a deformation of a rectangle acted upon on the narrow side by a system of forces of disappearing moment and disappearing resultant (in the plane of the rectangle), while the other three sides of the rectangle are free from stresses. It was found that the stresses in the rectangle, from the initial value, which they have in each of the narrow sides, diminish toward the interior of the rectangle very rapidly and nearly uniformly in accordance with the linear law and at a distance from the narrow side no greater than its own length hardly differ from zero. This holds even in the case where the length of the rectangle is about three times its width. (*Beiblätter zu den Annalen der Physik*, vol. 38, no. 21, p. 1297, and *Wiener Berichte*, vol. 123, pp. 33-51, 1914.)

Principle of Variation in the Theory of Elasticity.

The article discusses the application of the principle of variation in the theory of elasticity and its extension to the field of technical statics. It establishes two principles of variation. They are especially applicable to the treatment of lateral flexure of straight bars and bending of straight or curved bars.

If the principle of virtual displacements be applied to elastic bodies and only changes of shape be considered variable, it may be expressed in the following form:

$$\delta_1 [A - \Sigma Pw] = 0$$

where A is the work of change of form, or elastic potential, P the external acting forces, w their displacement along their direction lines, and δ_1 the variation in the change of shape. The author calls this equation the first principle of variation, and sets side by side with it, the second principle of variation which is derived from the principle of virtual displacement, by considering only the forces as variables. It is

$$\delta_2 [B - \Sigma Pw] = 0$$

where B (in accordance with the notation of Engesser), is the supplementary work or work of potential, and δ_2 indicates that the variation refers only to the forces. (*Beiblätter zu den Annalen der Physik,* vol. 38, no. 21, p. 1298, and *Zeits. für Mathematik und Physik,* vol. 63, pp. 174-192, 1914.)

Torsion Strength of Reinforced Concrete Beams.

The article discusses the torsion strength of reinforced concrete beams and shows experimentally how cracks develop when beams are subjected to torsional stresses.

The stressing of reinforced concrete parts in torsion does not occur frequently, but may occur when a beam is stressed normally to the plane of bending. The calculation of torsional stresses even in homogeneous and isotropic materials of construction is only imperfectly possible and then only for rectangular cross-sections. It is natural, therefore, to expect that an exact calculation of stresses in the case of compound bodies would be still more difficult. It is possible to consider the reinforced concrete beams stressed in torsion as divided into two parts, one of which is stressed in bending exclusively (Fig. 3 A). Instead of the moment of torsion $M = Ph$ we may write

$$Q \cdot \frac{2}{3}h,$$

so that

$$Q = \frac{3}{2}\ P = \frac{3M}{2h}$$

The two parts of the beam may then be considered as stressed in opposite directions by the loads Q; the beams would have to be reinforced by steel as shown in Fig. B. This method of calculation would have nothing objectionable in it if the beams were actually divided into two parts before the rupture of these parts and were then stressed in bending. As a matter of fact, however, the rupture of a prism stressed torsionally is entirely different, as shown in

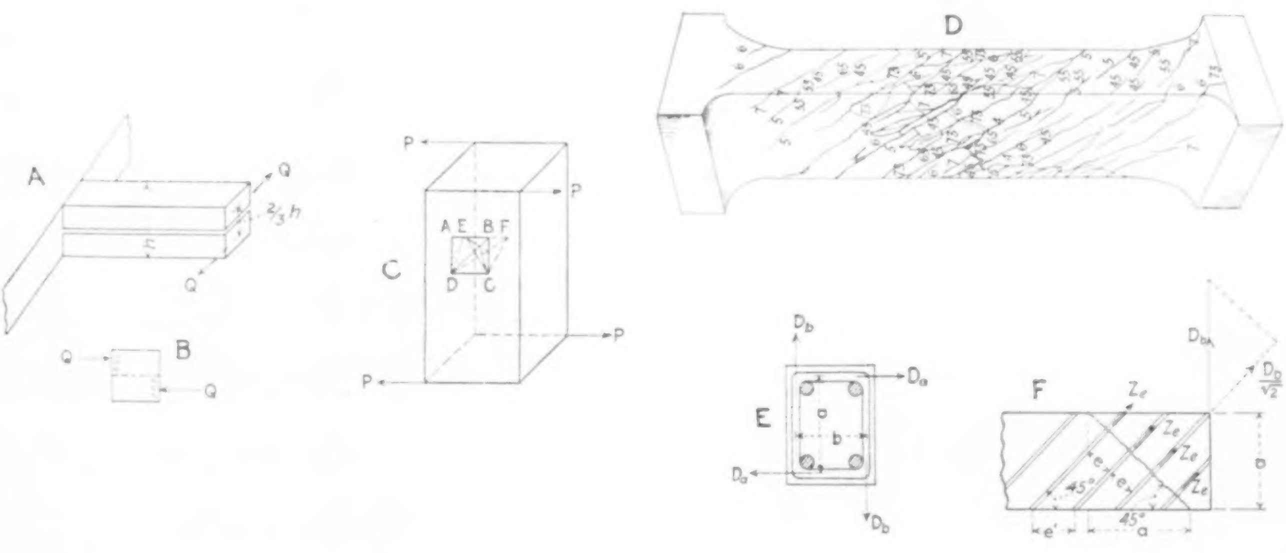


Fig. 3 Reinforced Concrete Beams in Torsion

Fig. D, which represents an actual case. This figure shows that the line of rupture on the faces of the prism run in inclined direction and this in its turn indicates that there are forces acting in torsion normally to these inclined lines, the rise of which can be explained in the following manner: In Fig. C is shown a prism stressed in torsion by two equal and oppositely directed couples. Owing to the change of shape, the original square *abcd* on one of the faces of the prism, is distorted into the rhombus *efcd*, while the diagonal of the square *db* is elongated into the rhombus diagonal *df*. If now the ductility of the material is exceeded, an inclined fissure will be formed normally to the diagonal *df*. In test pieces made of isotropic materials, the formation of fissures can be observed only imperfectly as the conditions of formation of the first fissures bring about a total exhaustion of the strength of the material, and produce rupture. The line of rupture, however, does not always coincide with the line of the fissures as by the appearance of the first fissure, a body of somewhat different dimensions is formed in which the line of rupture has a different location from that of the fissures in the original body. Tests with reinforced concrete prisms were the first to show clearly the processes of formation of fissures through torsion, as in that case the load up to point of rupture could be still considerably increased after the first fissures have appeared.

Fig. D shows clearly the fissures which have been brought about by torsion on the reinforced concrete prism of rectangular cross-section. The prism had six reinforced bars 18 mm. (0.708 in.) in diameter and eight spirals 7 mm. (0.275 in.). Its dimensions are shown in detail in the original article, which contains also another photograph showing the fissures in a prism under torsion making an angle of 45 deg. with the axis of the prism. Tests thus show clearly that on all the faces of a prism in torsion there occur fissures inclined 45 deg. to the axis and that the spirals running normally to these fissures are stressed in torsion. Usually before rupture, the fissures are shifted from the external faces of the prism into the interior in such a manner that tensions which produce these inclined fissures have to be taken up entirely by the inclined steel elements of the spirals. Generally the tensions are uniformly distributed among these steel elements, but as soon as any section of the reinforced elements' limits of elongation has been reached, the tensions begin to be distributed nearly uniformly in the planes of the spiral. For this state of tension, it is possible to calculate the tension in the reinforced elements.

The author proceeds to consider a prism of rectangular cross-section, the sides between the center lines of the spirals being *a.b.*, Fig. E. The moment of torsion is M and it may be considered as if consisting of two couples, each of the forces of these couples acting in a plane of the spiral.

$$M = D_a a + D_b b \quad [1]$$

This moment when the limit of elongation of the spiral has been reached produces equal tensions Z_e, normal to the direction of the fissures when inclined at 45 deg., Fig. F. The forces D_a and D_d have, each, in the plane of the spirals components $\frac{D_a}{\sqrt{2}}$ or $\frac{D_b}{\sqrt{2}}$ which act in the direction of the spiral elements. If there are in the a plane μ reinforcing elements and in the b plane ν reinforcing elements affected by the fissures inclined at 45 deg., then the forces D_a and D_b, acting from the outside, are in equilibrium with the external tensile strength strain Z_e if

$$\frac{D_a}{\sqrt{2}} = \mu Z_e; \quad \frac{D_b}{\sqrt{2}} = \nu Z_e \quad [2]$$

hence

$$D_b : D_a = \mu : \nu = a : b; \quad D_b = \frac{a}{b} D_a \quad [3]$$

and from [1] it follows that:

$$D_a = \frac{M}{2a}; \quad D_b = \frac{M}{2b} \quad [4]$$

Let us assume that the prism is equipped with k parallel spirals located at equal distances from one another. In a single winding, the spiral has the rise of $2(a+b)$, so that the spirals when measured in the direction of the edge of the prism have, from one another, a distance e' equal to

$$e' = \frac{2\,(a+b)}{k} \quad [5]$$

and the minimum distance e equal to

$$e = \frac{e'}{\sqrt{2}} = \frac{\sqrt{2}\,(a+b)}{k} \quad [6]$$

The lengths of the fissures inclined to one another to 45 deg. are

$$a' = a\sqrt{2}, \qquad b' = b\sqrt{2}$$

so that the number of the reinforcing elements affected by the fissures is

$$\nu = \frac{a'}{e} = \frac{k\,a}{a+b}, \quad \mu = \frac{b'}{e} = \frac{k\,b}{a+b} \quad [7]$$

By using these values in equations [7], [4], and [2], the

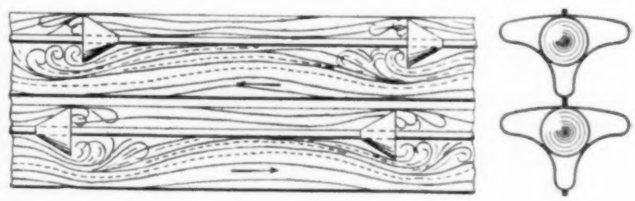


FIG. 4 SURFACE COOLER TUBES

author obtains the stress in the cross-section F_e of the spiral iron

$$\sigma_e = \frac{M\,(a+b)}{2\sqrt{2}\,F_e\,k\,a\,b} \quad [8]$$

which in its turn permits the determining of the number of the spirals k.

Refrigeration

IMPROVED SURFACE COOLER.

Description of recent advances of German milking machine design, and among other things, of several types of milk and butter coolers.

The abstract contains a description of such a cooler. It is of the surface cooling type (Fig. 4), and consists of seamless drawn, copper pipes, thickly galvanized, located one over another to a height of 2.5 m. (8.1 ft.) for large coolers. The water flows in countercurrent to the milk. In order to produce further a still better exchange of heat and in in this way save cooling water and especially space, a special round pipe was selected of the peculiar shape shown in the figure, which, within a small space, very materially increased the surface washed by the water. With a pipe so shaped, however, the automatic flow of water would not be as favorable as in the case of round pipes and in order to help

that out, at equal distances all along the pipe, very simple water-displacers have been located, as shown in the figure; this is claimed to assist materially the uniformity of the cooling action and thereby the better utilization of the cooling of the water. (*Die Fortschritte auf dem Gebiete der deutschen Molkereimaschinentechnik,* Ernst Kohl, *Dinglers polytechnisches Journal,* no. 42-43, p. 617, serial article, *d.*)

Miscellanea

THE DRYING OF SLUDGE AND ITS FURTHER USE.

The article describes an apparatus, based on the principle of centrifugal separation, for drying sludge.

It is designed by Hanoverische Maschinenbau. Akt. Ges. vorm. Georg Egestorf in Hanover-Linden, Germany, and the engineers of the city of Frankfort-am-Main. It has been known for a long time that by centrifugation, the sediment can be reduced to from 4/5 to 6/7 of its original volume, and this fact was placed as the basis of design in the new apparatus to take care of the very large amount of sediment in the Frankfort plant. In Germany, the amount of sewage waters in the cities varies from 100 to 200 l. (26.4 to 52.8 gal.) per day per unit of population in places where no particular causes for its increase are present, but rises to from 300 to 400 l. (79.2 to 105.6 gal.) per day per unit of population where there are extensive dye or laundry works. The sewage has been found to contain from 5 to 10 per cent of solid matter, and from 95 to 90 per cent of water.

The working process in the centrifugal separator is divided into two periods. In the first period, the sediment entering into the apparatus is dried by centrifugal separation of the water; in the second period, the solid particles remaining in the machine are eliminated. Fig. 5 A, B, C give several sections of the apparatus. The mud enters through the centrally located admission pipe *a* from a mud tank placed over the apparatus. Thence it goes into the centrifugal drum *b*, provided with several chambers equipped with screens *c* and inside and outside valves. It is there distributed through the separate chambers when the valve is opened. Through the action of the centrifugal force, the heavier particles of the mud are thrown into the external part of the chamber, while the specifically lighter water is forced out of the mud and flows out through the screens of the chambers into laterally located pipes, whence it is allowed to escape. The space which was formerly taken up by the water is then filled with a new supply of mud so that in a short time, the chambers are filled with mud practically free from water and air dried. Then the inner valve is opened,

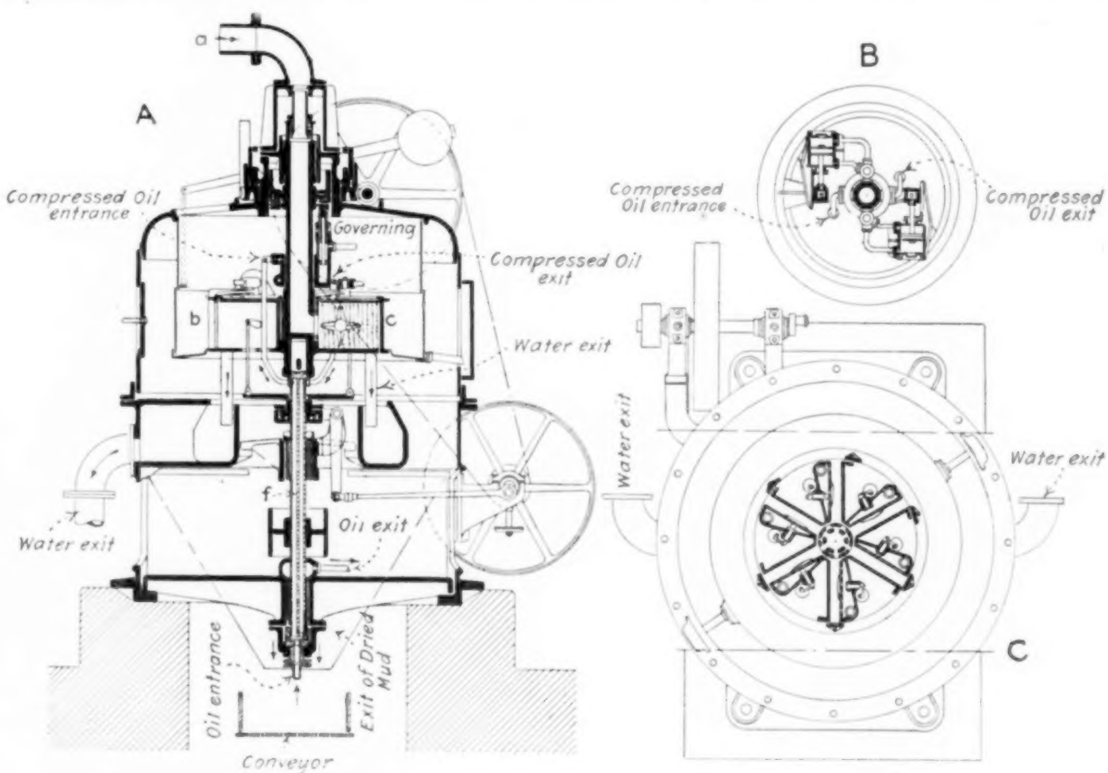


FIG. 5 CENTRIFUGAL SLUDGE DRYER

a further inflow of raw mud is admitted and the dry mass in the chambers is separated from the wet mud in the admission pipes. The external valve is then opened and the dry stuff is allowed to escape from the apparatus. Owing to the action of centrifugal force, the mass is violently thrown against the walls of the casing and thereby broken up into small particles. It is taken care of later by a conveying device located under the apparatus.

The violent action of throwing the mud against the screens tends to keep them fairly clean. In order, however, to insure more fully their cleanness, and in this way to prevent the stoppage of the flow of water, the screens are provided with a special mechanical cleaning device, viz., star shaped brushes which are given a reciprocal motion by a special drive. When the chambers are emptied, the outer valve is closed, the inner one opened and the process repeated. The valves are driven by oil under pressure which is admitted from below through a bore in the vertical shaft *f*. The admission of the oil under

pressure into the cylinder of the control valve is regulated by a rotating disc. The drum is enclosed in a strongly built casing and is driven by a belt. The parts of the casing which are subject to the action of centrifugally thrown masses are made of wrought iron. The drum shaft has three bearings, and in this way the weight of the drum is equalized through the oil under pressure admitted for operating the steering gear.

Around the centrifugal drum is located a concentric ring which takes up automatically the water escaping from the drum, and removes it shortly before the exit of the dry mass. After the dry matter has been taken care of, the ring returns automatically into its original position. This arrangement prevents the particles of water from staying on the periphery of the casing and mixing up again with the dry material thrown out by centrifugal force. In view of the great pressure exerted by the centrifugal force in the drum, it is impossible to prevent the appearance of water on the periphery of the casing even with the best packing of the valves, but the ring device described makes this water entirely harmless. The power consumption of this centrifugal separator is about 12 h.p. In order that the apparatus shall work without trouble, all large and hard pieces are removed previous to the entrance of the mud into the separator. This is easily done by passing it through a grating with slots 8 mm. (0.314 in.) wide.

The mass obtained from the apparatus can be used either for agricultural purposes or as filling material, and recently attempts were made to burn it in incinerators by gasifying it with some addition of coal. The tests of gasification and burning of the dried sewage sediment have been made at the Frankfort plant. The mud had been dried in the centrifugal apparatus to the extent of removing from 30 to 40 per cent of its water content. Then it was dried in drying drums by the use of flue gases down to 20 or 25 per cent of its water content, and in this state was added to the material fed to the incinerators in the ratio of one to ten. It was found that such an addition raised the output of electrical energy from 65 to 80 kva per 100 kg. (220 lb.) of mixture, which means an output of 150 kva per 100 kg. of mud. When the mud with 20 to 25 per cent water content is gasified, an average of 25 cm (per ? — not stated) of pure gas, with an average heat content of 4000 WE. at 448 B.t.u. per cu. ft. is obtained and, in addition, a valuable by-product secured, from 50 to 60 per cent of nitrogen contained in the sediment being converted into ammonia. The economy of the plant is still further increased through the utilization of the coke produced during gasification, which possesses a heating value of approximately 1200 WE. (2160 B.t.u. per lb.).

The article also contains data on the handling of the mud in municipal gas works of the cities of Brünn and Hanover. (*Trocknung von Klärschlamm und seine Verwendung*, Hubert Hermanns, *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 37, no. 44, p. 485, October 30, 1914; *d.*)

ENGINEERING SOCIETIES

THE COLD STORAGE AND ICE ASSOCIATION

Proceedings, vol. 11, no. 2, 1913-1914, London.

Multiple Effect Compression as Applied to CO_2 Refrigerating Machines, H. Brier

Cooling of the Liquid CO_2 in Refrigerating Machines, F. A. Willcox and G. C. Hodsdon

Excessively Dry Air in Cold Stores, Wm. D. Sawers (abstracted)

Excessively Dry Air in Cold Stores, Wm. D. Sawers (20 pp., *p*).

The author discusses the action of excessively dry air in cold stores on the goods stored therein and the various ways of mitigating and regulating such action.

The favored system of air cooling in cold stores is the so-called wet brine method in which the circulating air is cooled by direct contact with refrigerating calcium chloride brine. This method, which has its advantages, produces, however, a dryness of air due to the powerful desiccating action of calcium chloride at low temperature. It appears that as the temperature of the solution goes down, the desiccating properties increase to an enormous extent and comparatively weak solutions of the salt which at normal temperatures would evaporate, take in moisture in a rapidly increasing degree as the temperature becomes lower.

The author made a number of careful tests of the relative moisture-absorbing properties of different strengths of calcium chloride solutions at different temperatures. The solutions were left exposed to the air in rooms maintained at temperatures of 60, 35 and 17 deg. fahr. and the loss and gain in weight due to evaporation or absorption of water noted at intervals. Ordinary fused calcium chloride was used for making the solution and three different strengths were made, approximately 20, 25 and 30 per cent. solutions, the other conditions of the test being kept as far as possible identical. At 60 deg. fahr., the brine loses moisture in a lessening degree as the strength of the solution used is stronger. With 30 per cent. solution, the action comes to a standstill and it neither loses nor gains water. At 35 deg. fahr., 20 per cent brine gives up water fairly rapidly and 25 per cent brine neither gains nor loses weight, while 30 per cent brine absorbs moisture from the air rapidly. At 16 deg. fahr., 20 per cent brine slowly absorbs, 25 per cent rapidly and 30 per cent takes in moisture with great avidity.

It is evident, therefore, that the drying action of calcium brine becomes very much intensified if too strong a brine is used, consequently the making up of brine in a cold store is a detail that requires more attention than it usually receives, the general tendency being to keep the brine unnecessarily strong, which is due principally to a dread of the solution freezing on the ammonia coils. On the contrary, the brine should be maintained so far as possible at a constant minimum density by putting in the calcium chloride frequently and in small measured quantities. With constantly moving brine at a temperature of, say, six to nine degrees fahr., the density can be quite safely kept well below 1.155 sp. gr. ($17\frac{1}{2}$ per cent) at 60 deg. fahr. The author found that actual practice of this procedure effected a decrease in consumption of calcium chloride; for a space of 90,000 cu. ft., over three tons less chloride were used on a year's run as compared with previous working, while the appearance of certain classes of goods coming out of storage is distinctly improved.

The best way to obviate this difficulty would be to find some other chemical which would serve as a suitable substitute for calcium chloride in the brine, but which would be free from the drying action. Magnesium chloride also possesses strong drying properties. Common salt absorbs

moisture to a very slight degree, but its solution does not remain liquid at low temperatures. The author tested a brine made of mixed calcium chloride and common salt, but found that curiously enough, the calcium chloride seemed to convey its properties to the common salt and the solution was as active a dryer as if it had been made with calcium chloride alone and had the same density. He suggests, therefore, the use of a cooler in which the air passes over dry metal surfaces, so constructed that the snow, as it forms, may be continuously and automatically scraped and brushed off, but he does not describe its mechanical design.

ENGINEERING SOCIETY OF CHINA

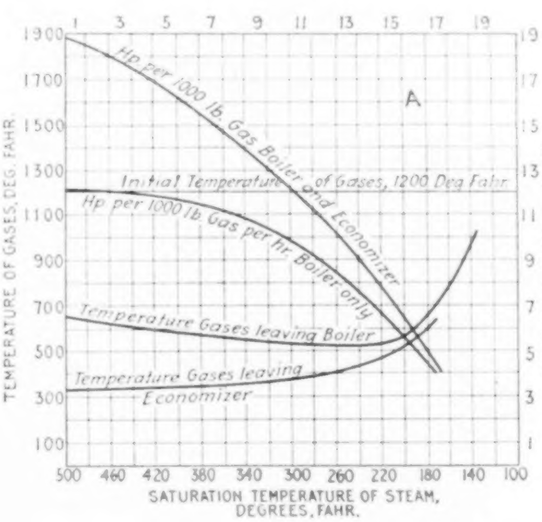
REPORT ON CHINESE CONCRETE.

The article gives a copy of a report made to the Engineering Society of China by a special committee which that Society appointed to investigate the question of reinforced concrete, such as preparation, strength, properties and use in engineering and building work, with special reference to local conditions in China. The article gives data on the materials used in the manufacture of concrete in China as well as the method of carrying out tests.

As the original publications of the Society of China are not available at the present time, the abstract is based on a reprint in *The Engineer* (London). The data of Table IV have been obtained. The results are by no means regular and the general superiority of the beams made with Pingchiao stone has been found in some cases. The difference between steel and iron is greatly in favor of the former. A consistent advantage was also found in favor of beams with hooked reinforcing bars as compared with beams with plain steel bars. In the case of iron bars, in some cases it was found that beams with hooked bars failed at a lower pressure than beams with straight bars. The first cracking invariably took place where the deflection was between $\frac{1}{16}$ and $\frac{3}{32}$ inches. At first, the cracks appeared distributed over the whole length of the beams at a distance of six to eight inches apart. With the increase of the load, the cracks nearest the center became larger, but when the maximum load was reached, with a deflection of $\frac{5}{16}$ to $\frac{3}{8}$ inches, a very distinct difference was visible between the beams reinforced with steel and those reinforced with wrought iron.

All beams reinforced with indented steel bars showed at the maximum load several wide cracks near the center tending to join each other at the top below the center where the load was applied. All other cracks further distant from the center had disappeared by then. Only three beams failed by the destruction of the bond between the steel and the concrete. All beams reinforced with wrought iron bars showed one large crack near the center, while all the other cracks had closed. In regard to slabs, those reinforced with steel failed more suddenly than those reinforced with iron.

Concrete was found to be less fire-resisting the greener and richer it was. None of the local materials can be considered as very fire-resisting in connection with concrete. Pingchiau stone, and especially gravel, have a tendency to destroy the concrete on account of their comparatively greater expansion. The report contains also data regarding the permeability of Chinese concrete and the effect of electrolysis. (*The Engineer* [London], vol. 118, no. 3072, November 13, 1914, p. 456.)



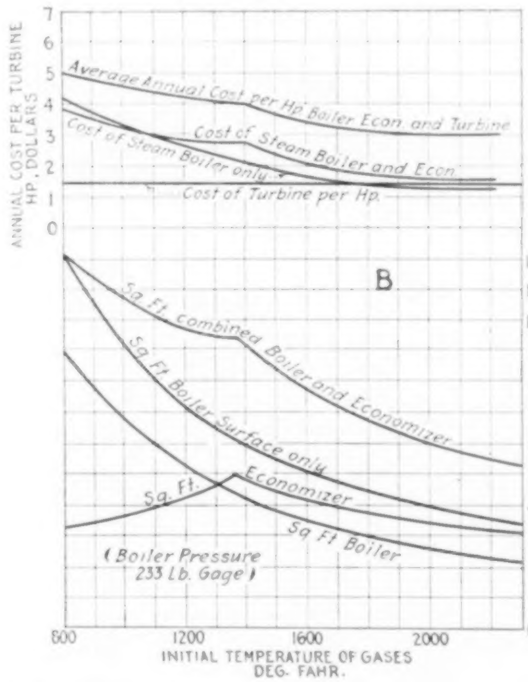


FIG. 6 COUNTER-CURRENT IN ECONOMIZERS

ENGINEERS' SOCIETY OF PENNSYLVANIA

Journal, vol. 6, no. 8, August 1914, Harrisburg, Pa.

THE COUNTER-CURRENT PRINCIPLE AS APPLIED TO DIRECTLY-FIRED AND TO WASTE-HEAT BOILERS, George H. Gibson.

The author discusses the use of economizers with directly-fired and waste-heat boilers and comes to the following important conclusion: *First,* that with directly-fired boilers, contrary to the usual assumption that economizers begin to be profitable only when the price of coal reaches \$2.00 per ton and the load factor exceeds 50 per

cent, actually, economizers can be used profitably regardless of the fuel price and of the load factor. *Second,* in the case of waste-heat boilers, such boilers and turbines should be put in for as high steam pressures as are practical in view of other considerations, and the boiler should be supplemented by an economizer in order to obtain the greatest amount of power and at the lowest cost from a given amount of gases.

The author reaches these conclusions in the following manner: He begins by establishing the margin of diminishing returns as applied to waste-heat and directly-fired boilers. In the first case, the principle of diminishing returns expresses itself by the fact that there comes an economical limit to the recovery of waste heat beyond which it does not pay for the increased investment. In directly-fired boilers, after the gases have been cooled to a certain temperature, the heating surface required to cool them further does not produce steam as cheaply as it can be produced by the heating surface, including the cost of fuel, preceding that point. Thus, if the gases are to leave the boiler at 200 deg. above the steam temperature, there will be generated approximately $4\frac{1}{2}$ lb. of steam per hour per square foot of surface, and about 6.5 sq. ft. of surface will be required to produce a boiler horse-power of 30 lb. of steam per hour. With steam at 366 deg. fahr., the flue gases will be at 566 deg. and will still contain a large proportion of the total heat of the fuel. Assuming that 24 lb. of air have been used to burn one pound of combustibles, the loss will amount to approximately 25 per cent, and after allowing for radiation and other losses, the boiler efficiency will be less than 70 per cent.

To recover this heat by means of heating surface and steam temperature is not profitable, but it may be so done by giving up the heat to the boiler feed water in the economizer where, assuming that the economizer's heating surface will have the same coefficient of transmission and the same fixed charges as the boiler surface, we should theoretically be able to reduce the temperature of the flue gases in the above case to within 200 deg. of the initial water temperature, i.e., to 300 deg., with a saving of approximately 13 per cent of fuel (actually somewhat more, because the economizer surface costs less per square foot to install and requires less attention).

The author discusses in an interesting manner the rate of heat transmission in the case of the economizer, as well as the question of the coefficient of heat absorption by convection or contact. If cooled to within 200 deg. of the steam temperature, the gases from a directly fired boiler will not be sufficient generally to raise the boiler feed water to near boiling point, but as the water in the economizer is lower in temperature than the water in the boiler, the economizer surface is more active and hence more profitable than boiler surface up to the point when the water reaches the boiler temperature. It would pay, therefore, to reduce the amount of boiler surface per h.p. developed to less than $6\frac{1}{2}$ sq. ft. per h.p. required to cool the gases to within 200 deg. of boiler temperature. The author gives as an example a description of a 1000 h.p. boiler, superheater, economizer and mechanical draft unit, laid out according to proportions determined in his discussion, and shows how this installation confirms his views that if an economizer is not installed, the boiler must accomplish the same office in heating the water up to evaporation point, but will do it with a lower efficiency because the boiler also contains water at the steam temperature while the economizer utilizes the lower initial temperature of the water to increase the heat absorption.

In the waste heat boiler, if the steam temperature is near the initial gas temperature, the boiler must be large because of the small temperature difference available for transmission or inefficient because it must allow the gases to escape while still at high temperature. At the same time, the efficiency of the turbine or other engine will be good because of the high initial temperature and pressure. If the steam temperature be gradually reduced, the efficiency of the turbine will be poor, while the boiler required will be smaller and its efficiency high. Therefore, two solutions appear to be possible, viz., to have the boiler operate at a moderate pressure or to have a small boiler operate at a high pressure and another boiler and economizer at a lower pressure in connection with a mixed flow turbine receiving high pressure steam from a high pressure boiler and low pressure steam from a low pressure boiler.

It appears, however, that the commercially best and most practical solution is a high pressure boiler in combination with an economizer and a high pressure condensing turbine. For instance, at 366 deg. fahr., corresponding to 150 lb. gage pressure, about 12 lb. of steam are required per turbine h.p. (a turbine 65 per cent. Rankine efficiency, saturated steam exhausting to a 28 in. vacuum referred to a 30 in. barometer) at 212 deg. approximately 24 lb. of steam are required, but at atmospheric pressure the steam is worth only one-half as much per pound as steam 150 lb. gage, which determines to what extent it will pay to reduce the temperature of the gases by means of boiler surface. From Fig. 6, the curve marked "Temperature gases leaving boiler," it is seen that in any case it will not pay to reduce the temperature of the gases in the boiler below 500 deg. fahr., at least in competition with directly fired boilers burning \$1.50 coal. By installing an economizer to supply the heat required to raise the feed water from 100 deg. fahr. up to the evaporation temperature, the final temperature of the gases will be reduced as shown by the curve marked "Temperature of gases leaving the economizer." The higher the steam pressure carried, the lower the final gas temperature and hence the greater the capacity as well as the economy of the unit.

The most striking result, however, of using the economizer is the greater increase in horse-power obtainable from each 1000 lb. of gases as shown by the curve marked "Horse-power per 1000 lb. of gas from boiler and economizer," the increase at ordinary steam pressures being about one-third. To determine, also, the variation in the cost of power produced by using the economizer, it is necessary to fix the annual costs of the two kinds of apparatus (Fig. B). For the boiler \$2.00 per square foot has been assumed as the cost installed, including settings, flues and fittings, with an annual charge including repairs, depreciation and attendance taken at 17 per cent. For the economizer, the cost per square foot installed has been put at \$1.50 and the annual charges at 15 per cent. A high pressure turbine has been assumed to cost \$10.00 per h.p., installed complete with condensers and auxiliaries and the turbine receiving steam at atmospheric pressure, \$20.00 per h.p. From the curves of total cost, including the steam cost, it will be seen that if the plant is operated with saturated steam at the initial temperature of 400 deg. fahr., the annual cost per h.p. is \$4.10. The same with the turbine receiving steam from a directly

fired boiler using coal at $1.50 per ton would cost a little over $10.00 per year. From Fig. B it might appear, however, that when using the economizer, power costs more than when using the boiler only, but there the boiler is terminated at the point where it ceases to be able to compete with the directly fired boiler with $1.50 coal. From there on, the gases are allowed to pass through an economizer in which they give a better return, until they can reach the same limit.

In a plant where the waste gases would produce a surplus of power, it might not be advisable or necessary to add the economizer, but as soon as the need of burning fuel under boilers to produce steam for power appears, it will pay to add the economizer both because of the greater amount of power thus obtainable from a given amount of waste gases and because the power so obtained is secured more cheaply than it would be secured from a directly fired boiler.

(17 pp., 13 figs. *pe.*)

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Proceedings, vol. 30, no. 6, July 1914, Pittsburg.

Test of Large Reversing Engine and Rolling Mill, Karl Nibecker (107 pp, 56 figs. *edA*).

The article describes a twin tandem compound reversing

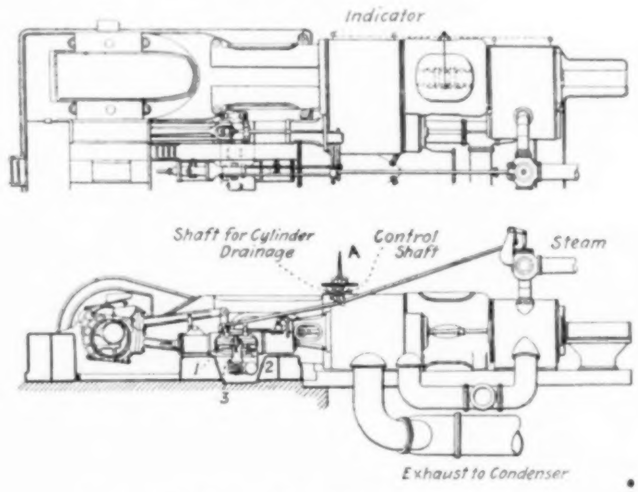


Fig. 7 Valve Gear of Reversing Rolling Mill Engine

engine driving a 44 in. reversing bloom mill when rolling 20 x 22 in. ingots, as well as the methods used in testing that engine and assumptions made in determining the power and steam consumption for this mill. Further, it considers the steam consumption per unit of metal deformed and the power losses involved in this operation.

The engine is operated condensing, using steam at 140 lb. gage pressure at the throttle valve and exhausting into a 28 in. vacuum. It is direct connected to the mill, but separated from it by means of a brick wall. Fig. 7 represents a diagrammatic arrangement of one side of the engine and valve gear, showing the method of control. It has been previously used in Europe, but is rather new in this country. The mechanism is operated by a single lever shown at *A*. This lever, located in a pulpit, operates the relay valve which controls the steam to the reversing cylinder operating both the reversing links and the throttle. The reversing piston is cushioned by means of a suitable oil cylinder connected to the reversing gear crosshead.

The three positions of the main reversing lever crosshead are shown by points 1, 2 and 3, the pressure of the steam through the throttle valve and the point of cut off being both determined by the motion of this cross-head, and it is essential therefore that the engine when operating under light loads, should work with the combination of throttle and cut-off control. The throttle valve is so arranged that its opening does not occur with the beginning of the movement of the reversing lever from its center position. A certain amount of lap is provided so that the valve gear is moved an appreciable amount from its neutral position before the steam valve is opened. When the throttle valve opens, the steam is admitted from auxiliary ports in the main piston valve. By this combination of lap on the throttle valve and auxiliary ports in the main valve of the engine, it is possible to start the engine at any position of the cranks. The auxiliary ports are in operation during the regular running of the engine but are too small to affect the economy of the engine or the shape of the indicator cards.

Continuous indicators were applied to each end of the four cylinders, equipped with electro-magnets for starting and stopping the paper and also for applying the pencil to the drums. The other four indicators were manually started and stopped at a given signal operated by the same key which actuated the starting magnets on the electrically operated indicators and were supplied with electro-magnets for locating the various events. The point of opening and closing of the steam throttle valve was recorded by means of one magnet. The position of the cross-head of the reversing cylinder was determined by a magnet on one of the indicators which indicated when the piston of the reversing cylinder was in its dead center position and when it was off the dead center position. The dead center position of this piston represented the point where the steam throttle valve was closed and the links were in their neutral position. On one indicator, a magnet was provided for recording one-half second intervals, thus giving a record of time. A figure in the original article is given to show the electrical connections but unfortunately it is too blurred to permit reproduction here. Storage batteries were used for furnishing the current for operating the instruments, and temperatures were read by means of a Wanner optical pyrometer. A three point recording thermometer was installed on the condenser and also a vacuum gage carefully calibrated by means of a mercury column.

The author describes in detail the methods used in working up the indicator cards which are those described by Siebert and Fitzgerald in the *Proceedings of the Engineers' Society of Western Pennsylvania,* volume 29, No. 8. It was found that 34.5 per cent of the total available work is consumed in accelerating and retarding the rotating and reciprocating parts, 9.8 per cent in friction and only 55.7 per cent is actually consumed in deformation of steel. The amount consumed by the engine in accelerating and retarding the parts is in this case inordinately large as tests on other engines have shown that this value can be as high as 15 per cent only and even lower. The engine in question, however, runs without the slightest vibration and has shown no wear on boxes, pins or bearings. While smooth running is a desirable feature, it does not always pay to spend too much in steam consumption to obtain it. On the other hand, the amount of power consumed in friction, 9.8 per cent, is exceptionally low and has been obtained by large short bear-

ings properly lubricated and by perfect alignment. The couplings used are of a special design and machined to eliminate all lost motion and reduce friction. Cut pinions are also used. The average value of the steam consumed per i.h.p. hour is only about 21 lb., which is exceptionally good.

This engine disproves the statement sometimes made that it is impossible to produce a high vacuum in the cylinders of a reversing engine since a vacuum of 25 in. in the low pressure cylinder has been here obtained with 28 in. in the body of the condenser. The author describes the low steam consumption of the engine to single lever control, and the consequent importance of using a large amount of steam for "plugging" the engine and throttling the steam for controlling the engine, as well as to well set valves giving high compression. At the same time, the engine has been found to reverse quickly: it requires approximately three-fifths of a second to move the lever through its entire travel and one and one-half seconds are required from the beginning of the movement of the reversing lever until the links are fully reversed. From one-half to one second is the time required for the links to reach their new extreme position after the lever has been thrown to its new extreme position.

The author calls attention to the excess of steam consumed per ton due to difficulty with manipulation of the piece and also to the piece not entering the rolls properly. With very little trouble, the steam consumption per ton can be increased 30 per cent, and it has been found also that one operator may use from 10 to 15 per cent more steam than another, although both may be considered expert engineers with a large amount of practice upon this mill. The author reproduces a table showing the increase which may be met with when rolling various sizes under different conditions of temperature and handling of the piece. In general, it appears that with a moderate amount of ordinary difficulty in manipulation and operation, the mill should consume less than 500 lb. of steam per ton of steel rolled constantly. A summary of the results as calculated by H. C. Siebert is given in Table 10:

TABLE 10 SUMMARY OF RESULTS

Set Number	7	15
Weight of Ingot—tons	2.74	2.46
Length of Ingot—ft. and in	4 ft. 9⅝ in.	4 ft. 2⅝ in.
Average Area of Ingot—sq. in	379	399
Section of Bloom—in	4⅞ x 6¾	7 x 5⅛
Area of Bloom—sq. in	32.9	35.9
Length of Bloom—ft. and in	55 ft. 0 in.	47 ft. 0 in.
Elongations	11.52	11.10
Indicated Work—h. p. sec	211,106	206,113
Friction Work—h. p. sec	37,465	33,690
Acceleration Loss—h. p. sec	61,901	77,014
Available for Rolling—h. p. sec	111,740	95,409
Friction Work—per cent	17.8	16.4
Acceleration Loss—per cent	29.3	37.3
Available for Rolling—per cent	52.9	46.3
Total Steam—lb	1,302	1,272
Steam per Ton for 11 Elongations—lb	475	515
Steam per i. h. p. Hour (Dry from Ind. Cards)—lb	17.1	17.1
Steam per i. h. p. (Plus 30 per cent for losses)—lb	22.2	22.2
Temperature—deg. fahr	2,245	2,200

In the discussion which followed, Charles Fitzgerald, Jr., took exception in regard to the test methods to the marking of one-half seconds points on the indicator paper for the purpose of plotting speed curves since the instantaneous linear speed of the paper is proportional neither to time nor to the speed of the engine. The curve plotted in this manner shows only approximately the general shape but is not valuable as a means of applying a kinetic energy factor to the solution of the problem of actual force applied at the rolls. The location of the passes by this method is also open to error unless checked by the indications of a correct speed curve which shows plainly the period of the bloom in the rolls. The speaker thinks that 18 lb. per i.h.p. looks too good to be true.

FRANKLIN INSTITUTE

Journal, vol. 178, no. 6, December 1914, Philadelphia, Pa.

Wing Data and Analysis for a Staggered Biplane, A. F. Zahm (16 pp., 9 figs. p.)

The article presents data for a staggered biplane with the spars continuous from body to wing and the angle of incidence varying with the speed, thus causing the line of resultant lift to travel.

The article is too long to be fully abstracted here and only certain parts will be given. Fig. 8 shows that as the wing of incidence varies throughout its assumed range of 0.5 to 12 deg., the center of pressure moves fore or aft through about one-fourth the chord; thence, if the spars be placed

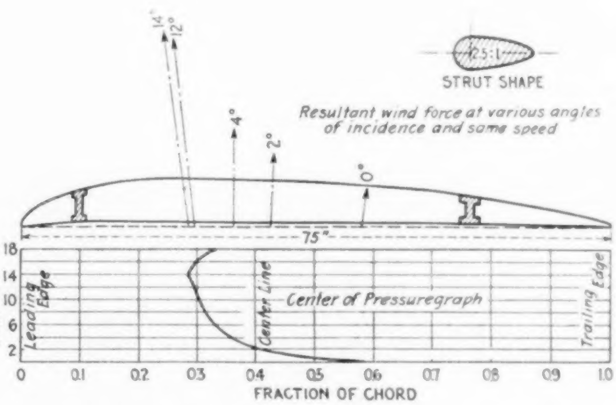


Fig. 8 Section of Wing. Strut Shape. Wind Force on Wing Plane

too near together, each spar in turn may have to sustain the whole load and the farther apart they are placed, the less the portion of the load varies In the wing under consideration, the spars can be placed 48 in. apart and yet have sufficient depth within the canvas. The running loads have been graphically resolved in the plan of the plane of the front struts and of the top spars to obtain the running loads in these planes and hence the tensions and compressions borne by the truss members in the planes. Likewise, they have been resolved in the plan of the spar web in order to define the bending moment of the spar due to the net running load on it.

For the spacing of the struts along the spars the following method was used. The distances between the struts along the wing were so chosen as to make the bending moment in any spar the same as that of its strut joints. Thus the overhanging wing end is a uniformly rotating cantilever beam and has a bending moment next the strut of $\frac{Wl}{12}$ if W be the known running load on the spar and l the length of the overhang. The next span is a uniformly loaded beam

with fixed ends and next to each strut, has the bending moment $\frac{Wl_2^2}{12}$, where l_2 is its length. The next span is a uniformly loaded beam fixed near to the strut and pinned at the engine section and next to the strut has the bending moment $\frac{Wl_3^2}{8}$, l_3 being its length. Since these three moments are to be equal

$$\frac{Wl_1^2}{2} = \frac{Wl_2^2}{12} = \frac{Wl_3^2}{8}$$

and since the sum of the span length equals the given wing length

$$l_1 + l_2 + l_3 = l$$

the equations can be solved for l_1, l_2 and l_3.

The article discusses in detail the graphical determination of the applied forces and reactions in the plane of struts and in the upper and lower planes as well as the assembled dimensions and computed values and proceeds then to the total analysis of stresses and loads.

NEW ENGLAND RAILWAY CLUB

November 10, 1914, Boston.

Typical Rail Failures, F. A. Weymouth (46 pp., 46 figs. *dp*). The paper describes various causes of rail failures, gives a classification of defects, and discusses the so-called frictionless rail.

A logical classification of rail failures seems to be one that places them under headings descriptive of the manner in which the failure develops or occurs in service. The author considers rail failure under four main headings: first, crushing of the head; second, flowage of the top metal of the head; third, broken rails, and fourth, rails worn out from abrasion. Under the heading of *crushed head failures* are placed all rails that indicate a flattening of the head or breaking down of the head structure, *i. e.*, the under side of the rail head shows distortion. Many of the crushed-head rails are called also "split-head" when they show a splitting of the head; but this term is merely an amplification of the term crushed-head. Some rails are termed "piped," which suggested that this type of failure comes from the presence in the rail of unwelded surfaces of the original cavity of the ingot. Naturally, however, only very few failures are traceable to this cause and it seems best to use the term "crushed-head" in all such cases.

Crushed-head rails in track are readily detected in three ways: first, a widening out of the head is very apparent in tracking; second, a dark streak appears in the center of the top of the head of the crushed portion, indicating that that portion of the metal is depressed and is not receiving the usual brightening from the wheels; and third, the distortion or breaking down of the head structure can be detected by a sufficient template or the appearance of a ferro streak in the head. The crushed head occurs partly because of the battering of the top surface of the metal due to low joints and also because of uneven tamping of the ties. It may occur in unsegregated rails as well. This has been shown by a special machine designed at the Maryland Steel Company for the purpose of reproducing the condition of the wheel loading that the rail gets in service.

The term "flow of metal" failure is used to describe rails that show a rolling-out or *flowage* of the top metal of the head toward the sides without a breaking down of the head structure. It may occur in many different forms and be due to various causes, such as improperly maintained or poorly designed joints, a vertical movement of the rails and especially the effect of different types of supports. One of the most annoying types of flow metal is that which has been given the name "flow in spots," which causes what is sometimes called a "roaring" rail. These spots occur on the gage corner of the head. No satisfactory explanation of this type has been evolved, but intense localized wheel pressure which stretches the metal beyond its elastic limit is one of the causes mentioned. The effect of slipping drivers and all slipping wheels is also very marked in the development of rails that fail from flow of metal. While flowing metal itself is not dangerous, it may form a starting point for the development of splits, crushed heads and breakages.

The author proceeds to discuss failures from breakages such as flange breaks, breaks across the rail section, and breaks in the web. He discusses the claim that flange breaks are the result of lack of transverse ductility in the rail accompanied by the presence of seams and agrees with the view that a large number of flange breaks are due to the presence of seams which are elongations of small cracks formed in the ordinary process in rolling the ingot. As regards the action of slipping drivers, an investigation was made by placing in one of the tracks of the Maryland Steel Company a rail which was then slipped on by a light locomotive. The rail was then removed from the track and bent under the tensile machine. At the part where the rail was not slipped on, it stood a load of 200,000 lb. without fracture, while at the point where the drivers had slipped on the rail, it broke at 160,000 lb. pressure. Scleroscopic hardness tests made on that part of the section showed 80 hardness against 37 for the average for the rest of the metal in the head.

The name of transverse fissure is given to a fractured rail section that shows smooth track or silvery spots in the head, while the rest of the metal is granular. It is found on the fractured surface usually without any connection with the outside skin of the rail, indicating that it is an internal fissure that radiates from a nucleus. No satisfactory explanation of the cause has as yet been evolved.

As regards rail abrasion on straight track, normally only simple flowage is found due to the wheel pressure and the wearing away of the top fillet of the rail on the gage side to fit the nuts of the wheel flange or on curves; a number of different types of rail wear is found, each imposing a different set of strains upon the rail. The author proceeds to discuss the wear on the high rails, the influence of worn wheels on the shape of the rail (formation of false flange on the rim) and finally the use of the so-called frictionless rail.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Advance copy of paper read at meeting on November 27, 1914, Newcastle-upon-Tyne.

The Remarkable Failure of a Consignment of Steel Ship Plates, W. J. B. Wilson (11 pp., 11 figs. *deA*). The paper describes an unusual failure of steel plates used in the construction of an ice breaker and the tests performed on these plates. It shows that such usual tests as chemical analysis, tension, bending, punching and forging tests, as prescribed by Lloyd's, are not always sufficient to determine the properties of the material, and steel which fully satis-

fies such tests may prove to be entirely unfit for service under these difficult conditions (winter service, etc.).

In 1907, the author's firm received an order for an ice-breaking cargo and passenger steamer to be built to Lloyd's highest class under special survey. The material for the shell had been tested and passed by Lloyds and characterized by the surveyor as excellent. In punching the garboard strake plates, several of them cracked, the failure having been put down to the severe cold prevailing (-13 to 18.4 degrees fahr.). Later on a number of garboard plates cracked between the rivets, and some of them were so brittle that a single blow with an ordinary hand hammer knocked pieces out of the flange portion. The job of riveting the keel was at once stopped until a thorough hammer test of the flange portion of all the remaining garboard plates had been made. This proved perfectly satisfactory and the riveting was resumed. For some time practically no cracks occurred, then the cold again became very severe and several days later, one of the garboard plates which had been riveted in the ship was found to be badly cracked, the crack being clearly a case of spontaneous rupture. When this plate was cut out, the material in the way of the keel rivets cracked in the same way as the one described above and a new hammer test was made therefore with the startling result that every plate in the garboard plates cracked and in some cases, pieces fell out. A new survey was then made by Lloyds which proved satisfactory to the surveyor. The bend tests were excellent so long as the test pieces were not taken near any rivet holes. Chemical analysis for phosphorus was good, but still one blow of a heavy hammer was sufficient to knock large pieces out of the flange portion of the plate.

The article gives extracts from an official report of tests made, which indicated that the plates satisfied all usual requirements; after these tests have been made, the surveyors maintained that as the steel passed the test laid down in the rules, they were not justified in blaming the material unless a test could be devised which would, in their presence, prove the steel to be at fault. The author then devised a test carried out in the following manner: a butt strap which had not been worked into the vessel and a plate of material made in a Swedish steel works were placed in a mixture of ice and salt and the temperature of the plates reduced to -4 deg. fahr. The plates were then quickly punched on one side for double riveting and riveted together, care being taken that the edges of the plate opposite the holes were kept cold with ice. After the plates were allowed to cool down, the rivets were driven out, during which operation the plate taken from the ship's material cracked badly and pieces dropped out. The plate from the Swedish steel works was also inspected but did not show any signs of cracks. These butt strap tests were sufficient to show that the material was really entirely spoiled by riveting, and that the Swedish material, although worked in the same way, gave no trouble at all.

The case of the plates was submitted to Prof. J. O. Arnold of the University of Sheffield, who made the following report. The chemical analysis was:

Chemical Analysis

	Per cent		Per cent
CC.	0.05	S.	0.08
Gr.	trace	P.	0.06
Si.	0.08	As.	trace
Mn.	0.86		

The material is a dead-mild steel which, from a chemical point of view, is not of very good quality. A micrographic examination of the material showed the structure reproduced in the accompanying micrograph (Plate 1.). The very small carbon contents are centered into dark etching areas, best described as the fourth phase of pearlite, namely, when it is passing into ferite and massive cementite. When such high sulphur as 0.08 per cent is present, dove grey areas of sulphide of manganese are scattered through the steel in very appreciable numbers. The crystals have sharp angular boundaries; indeed, the material appears to have been overheated in the manufacture, and gravely injured by the operation.

A number of alternating stress tests were made, giving extremely unsatisfactory results. The conditions of testing were the standard method adopted here, viz., the bars were $\frac{3}{8}$ in. diameter, and the distance from the zero of stress to the plane of maximum stress 3 in.; the deflection each way on the zero plane was $\frac{3}{8}$ in., and the rate of alternation 650 per min.

Good mild steel should endure a minimum of 300 alternations of stress. The faulty steel, however, in 8 tests averaged only about one-third of this, or 100 alternations. This is the worst steel of its class I have ever examined under alternating stress.

I have not had the tensile tests made, as in such cases these would be of very little use, usually giving very fair results. As regards the bends, I send also three of the bars used in the alternating stress tests. As you will see, they have bent double without any sign of a flaw. This also is quite usual.

I am a little puzzled as to the origin of this steel, since the high silicon, 0.08 per cent, suggests an acid steel. It may, however, be a basic steel, overtreated with ore, to which manganese and silicon have been added in the ladle. If the carbon were, say, 0.2 per cent instead of 0.05 per cent, I should with some confidence class it as Bessemer steel; as it is, I find it difficult to suggest its method of manufacture with any degree of certainty.

The overheating to which I referred would take place in manufacturing the plates from the slab ingots. When such ingots are heated to too high an initial temperature and rolled, they leave the rolls at too high a temperature, cool too slowly and crystallize, and if such plates are stacked in heaps to cool, it is obvious that the cooling is still slower, and the crystallization more perfect, and hence more dangerous. . . .

This shows that the ordinary methods of testing, such as adopted by Lloyd's, are not sufficient to detect certain kinds of weaknesses in the materials; this is of extreme importance in ship construction on account of the tremendous stresses to which boats built for winter traffic are subjected. Only the very finest material can be used in such cases and had, for example, this vessel been launched without notice having been taken of the first crack, it would have been classed as 100 A-1, but the very first attempt at ice breaking would doubtless have ended disastrously.

OHIO SOCIETY OF MECHANICAL, ELECTRICAL AND STEAM ENGINEERS

Journal, vol. 7, no. 1, November 1914, Columbus, O.

Centrifugal Pumps for Boiler Feed Service, Edward S. Adams

Some Chemical Aspects of Boiler Feed Waters, Charles W. Foulk
Cooling Towers and Cooling Ponds, Walter G. Stephan (abstracted)
Coal Crushing Equipment for Power Plants, George D. Francisco
Technical Museums, Frank E. Sanborn
Safety First as Applied to Traveling Cranes, Henry F. W. Arnold

COOLING TOWERS AND COOLING PONDS, Walter G. Stephan (4 pp., *gd*). The article discusses the design and use of cooling towers and cooling ponds in connection with the installation of condensing apparatus, the theory of their design and some tests made on cooling towers.

In the best commercial practice with the forced draft towers, it is possible to cool water to a temperature of about 15 deg. above the temperature of the dew point. With the natural draft tower, it is practical to cool to 20 deg. above the temperature of the dew point. The drop in temperature can be made considerable, but it seems to be more difficult to cool from 95 deg. to 85 deg., for example, than it is to cool from 125 deg. to 85 deg. with the same atmospheric conditions. The author gives formulas for the determination of the heat given up through convection and evaporation by water pumped over a cooling tower. With other conditions remaining the same, the temperature ratio of air-out to water-in represents the real efficiency of a cooling tower. In a well designed cooling tower, the humidity of the air leaving the tower is always 100 per cent. The terminal temperature difference will vary anywhere from 5 to 15 or 20 deg. Interesting tests on cooling towers were made by the Wheeler Condenser and Engineering Company of Carteret, N. J., the results of which are printed in Table 2:

TABLE 2 TESTS ON A FORCED DRAFT COOLING TOWER

AVERAGES OF THREE HOURS READINGS

Water				Air				
Gal. per min.	Temperature Deg. Fahr.		B. t. u. per min.	Temperature Deg. Fahr.		Humidity Per Cent		Quantity measured by anemometer Cu. ft. per min.
	In	Out		In	Out	In	Out	
651....	105	84.7	110,000	71	90	40	100	53,900
638....	107.8	87.5	108,000	72	93	60	100	50,100
638....	112	88.5	124,500	64	96	60	100	51,400
643....	108.5	87	115,000	69	92	48	100	52,200
640....	109.9	90.5	103,400	83	95	48	100	50,600
*632....	116	98	94,800	43	101	75	100	23,500
*630....	135	115.8	102,000	60	118	73	100	15,575

* Natural draft, fan not running.

The quantities of air were obtained by anemometers which were moved back and forth across the top of the tower at regular intervals and the results obtained were corrected so as to give the correct amounts entering the tower. The water was measured both by a Venturi meter and a calibrated Pitot tube.

In later experiments made with a view to increasing the efficiency of the towers, the quantity of air was not measured but the following results were secured in which it is to be noted that the temperature of the out-going air is only 3 deg. below the temperature of the in-flowing water. This test was made on a large installation consisting of a special Wheeler-Balcke forced draft tower.

Water	Gal. per min.	3200
	Temp. in	109 deg.
	Temp. out	97 deg.
Air	Temp. in	91 deg. humidity 59 per cent.
	Temp. out	106 deg. humidity 100 per cent.

It is quite possible to cool water below the temperature of the air, this depending, however, on the air humidity. It is of course important to secure the lowest practical temperature of cooling water. A difference of 10 deg. lower initial temperature of the circulating water in a surface condenser may mean a difference between a vacuum of 27 in. and a vacuum $27\frac{3}{4}$ in., and $\frac{3}{4}$ inches of increased volume may mean quite a large saving in coal cost per year.

WESTERN SOCIETY OF ENGINEERS

Journal, vol. 19, no. 8, October 1914, Chicago.

The Future Sanitary Problem of Chicago. A Symposium, E. H. Lee, J. W. Alvord, George A. Soper, John D. Watson, Arthur J. Martin

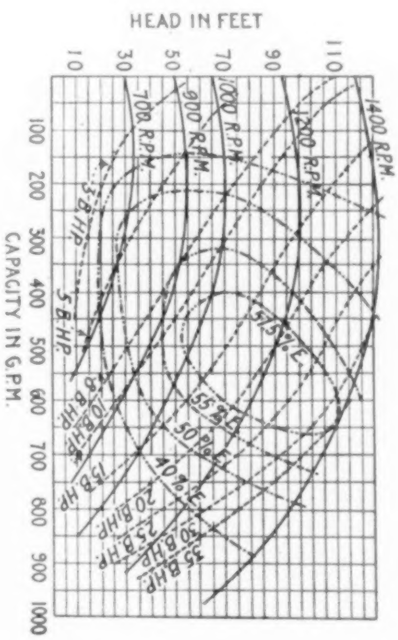


FIG. 9 CHARACTERISTIC CURVES OF CENTRIFUGAL PUMPS

Characteristic Curves of Centrifugal Pumps, F. William Greve, Jr. (abstracted)
Sewage Disposal Plant at Aberdeen, South Dakota, W. G. Potter

CHARACTERISTIC CURVES OF CENTRIFUGAL PUMPS, F. William Greve, Jr. (12 pp., 5 figs. *et*). The article treats of characteristic curves of centrifugal pumps as a means of illustrating a method of diagramming experimental data pertaining to centrifugal pumps. The curves deal with the head, speed, capacity, horsepower, input and output, and efficiency of a four-inch centrifugal pump.

The article contains five diagrams, of which only diagram Fig. 9 is reproduced here. Three series of curves have been plotted on it, the set showing the relation between head in feet and capacity in gallons per minute with the speed remaining constant for any one curve, and shows how the head decreases with increase of capacity except for very small discharges. At the same time, the maximum head does not

occur at the minimum discharge but at a point equal to about one-third of the maximum. If continued, these curves would have dropped on a line approaching the vertical. Another diagram illustrates the changes in efficiency for various values of capacity when computed for a constant speed. Up to a certain limit (variable) the maximum efficiency and capacity are found to increase with an increase of speed. For small discharges the efficiency is practically the same at any speed, and in general, the shape of the curves resembles a semi-ellipse. The horsepower input is found to increase with the discharge after a given speed until the point of maximum capacity has been reached when the curve becomes horizontal. The curves determining the range in head for various speeds with the discharge remaining constant approach closely those of straight lines and for large quantities may be assumed as such. In the diagram (a series of curves drawn from the upper left to the lower right end of the sheet show the horsepower required to discharge any quantity of water against any head and at any speed within the limits of the pump. The author fully explains the method of determining these curves and especially the use of interpolation.

The efficiency curves are similar to an ellipse, the major and minor axes of each curve intersecting in a common point of origin, which is also the point of maximum efficiency. The fact that these Iso-Efficiency curves are concentric is important, as when the efficiency is required for which no curves have been drawn, a new curve may be sketched in with reasonable accuracy. The advantages of representing the determinations of a pump by such curves lie in the fact that in any series of curves on the diagram, the curves are parallel or nearly so. This diagram may be considered to represent a map upon which the characteristics of the pump are indicated so that questions referring to the relations of speed, discharge, head pumped against, horsepower input and output may be answered by reference to it. The author points out that when more than one diagram is used in representing test results, there is danger of error when the eye is deflected from one diagram to another and that a single diagram is more convenient.

In the discussion which followed, Mr. H. S. Baker told of the wide adoption of centrifugal pumps in city water works. The city of Chicago has a number of such pumps, as well as the cities of Toronto, New York and Buffalo. The city of Cleveland has just purchased a twenty-five million gallon unit to work against a head of over 200 ft., while the city of Philadelphia has received bids for a number of centrifugal pumps to be driven by steam turbine.

Mr. Bowen told of a curious experience of a friend of his who has charge of seven large pumping stations with heads ranging from 85 to 340 ft. "He has no centrifugal pumps, but he made a statement to me which was indeed very interesting. From one of these stations, which is used for irrigation purposes, the water is taken off at several different levels, making several different heads; and the statement he made was, that when the water was taken off the discharge line at maximum head, the fuel consumption was quite a little greater than when a portion was taken off at high level and a portion at low level, and when the pumps were running at the same speed and therefore delivering the same volume of water. The head of pump, as indicated by gauges, was exactly the same in each case, which would indicate that the pumps were doing exactly the same work under the two conditions, but the fuel consumption was different. If this is true, which is hard to conceive, then perhaps the testing of pumps in manufacturers' plants, where heads are created by a valve in the discharge line, may give results which will differ when the same head is obtained in actual operating conditions."

Vol. 19, no. 9, November 1914

PERMEABILITY TESTS ON GRAVEL CONCRETE. Morton O. Withey (46 pp., 20 figs. *eA*). The paper is a preliminary report on tests now conducted at the University of Wisconsin to determine the permeability of concrete to water, started at the suggestion of the Inspection Bureau of the Universal Portland Cement Company. The tests cover the effects on permeability of age, thickness, consistency of concrete, time of mixing, gradation of the aggregate, wet and dry sand, fineness of cement, and curing conditions. Only tests on gravel and sand aggregates are here considered, although work is being done on mixes containing sand and broken stone. The tests are somewhat unique because of the use of machine-mixed concrete and the employment of large specimens having a prescribed volume of concrete subjected to water pressure and the measurement of the water entering the specimens during a large number of hours.

The results of the tests are presented in the form of tables and sometimes curves. None of the test pieces showed visible signs of leakage, but from various evidence, it seems certain that the water went through the specimens and it is indicated that the rate of flow for the 20 to 50 hr. period on a specimen which has previously been subjected to water pressure is about the same as the rate for a similar specimen tested for the first time and it appears that the permeability of so-called impervious concrete is unaffected by age after being properly cured for one month. It appears that the rate of flow for specimens having no visible leakage is independent of the thickness, although it is barely possible that the pores in the top surfaces of the thin specimens were sufficiently compressed by the bending of the core under pressure to reduce the rate of flow. The effect of grading the sand and gravel into different sizes and recombining these sizes in such a way that the maximum density may be obtained, has been very carefully studied. If mixes containing practically the same proportion of cement by weight are compared, it will be found that the batches which were most impervious were of 1:5, 1:7 and 1:9, and most of the mixes have a higher proportion of fine particles than demanded by Fuller's theoretical curve.

In general, it was observed that the flows decreased as the density increased, and one of the figures indicates that either the ratio of the volume of the cement particles to the volume of air voids in a unit volume of concrete or the ratio of the volume of cement particles to the volume of air plus water voids furnishes an index of imperviousness, the former seeming a better index than the latter. It appears further that permeability is influenced much more than strength by a change either in the proportion of cement or in density.

From these tests the following conclusions applicable to concrete made of like materials may be drawn:

1. None of the concretes tested were absolutely watertight if we consider continuous flow into the specimen as proof of permeability, but the majority of the mixes were so impervious that no visible evidence of flow appeared. For most purposes such mixes can be considered watertight.
2. The visibility of dampness on the bottom of the specimens increased with the humidity of the air and the non-homogeneity of the concrete. The minimum rate of flow for which leakage was indicated was 0.00011 gal. per sq. ft. per hr.
3. In tests of nearly all of the properly made mixes of 1:7 proportions, or richer, the rate of flow for a fifty-hour period was less than 0.0001 gal. per sq. ft. per hr. under a pressure of 40 lb. per sq. in.
4. Through increasing the fineness of the cement, a reduction in the rate of flow and a considerable increase in the strength of a 1:9 mix were secured.
5. By grading the sand and gravel in accordance with Fuller's curve, it was possible to obtain practically watertight concrete of 1:9 proportions under pressure less than 40 lb. per sq. in. To secure such results, however, requires great care and careful supervision in mixing, in determining the proper consistency, in placing, and *in curing* the concrete.
6. In the proportioning of such materials as these, volumetric analysis coupled with a determination of the density and air voids yields very valuable information concerning the best proportions of sand and gravel for a given proportion of cement. If proportions must be selected arbitrarily a $1:1\frac{1}{2}:3$ mix, by volume, is very impervious. It should be remembered, however, that the volume changes in rich mixes due to alternate wetting and drying are much greater than for lean mixtures. Consequently, due attention must be given to the provision of expansion joints and reinforcement in structures made of them.
7. The use of the proper amount of water necessary to produce a medium or mushy consistency is one of the most important conditions in securing impervious concrete, especially when lean mixtures are used. Dry mixtures cannot be sufficiently compacted in the molds and are more difficult to cure properly than the mushy mixtures. Although the use of a wet consistency does not materially affect the imperviousness of very rich mixes, such as $1:1\frac{1}{2}:3$, it greatly increases the flow through a lean mix.
8. For lean mixes made from damp sand it seems advisable to mix longer than is now the common practice. These tests would indicate that for a mixer running at 30 r.p.m., a period of one and one-half to two minutes is required to secure thorough mixing of a 1:9 concrete. for a rich $1:1\frac{1}{2}:3$ mix a one-minute period appears to be sufficient. The method of mixing in which water is first admitted to the mixer is to be condemned. A preliminary period of drying mixing lasting from 15 to 30 seconds seems desirable.
9. No stage or process in the making of impervious concrete is of more importance than curing. The results of these tests clearly demonstrate that premature drying destroys the imperviousness of 1:9 mixes, seriously impairs that of the 1:2:4 mixes and somewhat diminishes that of the $1:1\frac{1}{2}:3$ mixes. For thin sections, not over 6 or 8 in. thick, the curing conditions should be such that a lean concrete will be kept damp for a period of one month and a rich concrete for at least two weeks. Even after a month of proper curing, complete desiccation of a lean mix composed of these materials produces an increase in permeability, but the effect on a rich mix is not marked.
10. In these tests, the imperviousness of the concrete increased rapidly with the age of the specimens for the first month; thereafter the change was not marked.
11. From the tests thus far made it seems probable that the permeability of lean concrete in a direction normal to the pouring is greater than in the direction of pouring.

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The various articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

MEETINGS

ATLANTA, SEPTEMBER 19

The second annual barbecue of the Affiliated Technical Societies of the City of Atlanta was held on the grounds of the City of Atlanta Pumping Station on September 19, 1914, with about 80 men present.

These meetings are held for the purpose of stimulating interest in the various local organizations, promoting the welfare of the national societies and advancing the interests of Atlanta. The following organizations were represented: the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Chemical Society, the Engineering Association of the South, the American Institute of Architects, and our own Society.

The meeting was called to order by A. M. Schoen, chairman of the executive committee of the affiliation, who briefly outlined the object of the meeting, its plans and expectations. He was followed by Paul H. Norcross, member of the Engineering Association of the South, who spoke upon the benefits of such gatherings and the fraternal spirit of the affiliation. Prof. T. P. Branch, a member of the American Society of Civil Engineers and of the Engineering Association of the South, spoke of the need of technical men in all technical positions. An interesting talk upon Physics and Chemistry, together with the importance of chemical manufacture, was given by Dr. J. T. Brogden, member of the American Chemical Society.

Gabriel R. Solomon, member of the American Society of Civil Engineers and of the Engineering Association of the South, then read a paper on the necessity for the engineer in public service, in which he said that the lack of recognition of the engineer by the public was largely his own fault because he is an indifferent citizen. The engineer needs to get into touch with life and to cease to hold himself aloof from public affairs while there are public questions of engineering interest which await an expression of intelligent and trained opinion.

Short talks were also given by Frederick Kloepper, of the American Institute of Architects, Prof. H. P. Wood, member of the American Institute of Electrical Engineers, R. D. Kneale, associate professor of civil engineering of the Georgia School of Technology, and Dan Cary, superintendent of parks and playgrounds. The last speaker laid stress on the necessity of expert advice in connection with city planning.

ST. LOUIS, OCTOBER 28

At a meeting of the Associated Engineering Societies of St. Louis, held on October 28, under the auspices of the local section of the Am.Soc.M.E., John Hunter gave a very interesting paper on The Development of the Central Station. The paper was illustrated by lantern slides, showing central stations in Boston, New York, Albany, Philadelphia, Detroit, Milwaukee, Chicago and St. Louis. The paper was discussed by those present.

BUFFALO, NOVEMBER 5

At a meeting of the Buffalo Engineering Society on November 5, J. Irvine Lyle of New York addressed the society on Industrial Ventilating and Cooling Equipment. Mr. Lyle gave some very interesting facts regarding some recent installations in cotton mills, tobacco manufacturing plants, automobile plants, etc., for the purpose of air conditioning. His address was illustrated by lantern slides showing the construction and arrangements for the distribution of the pure air. There were about 120 members present.

NEW HAVEN, NOVEMBER 18

The Fall Meeting in New Haven was held at the Mason Laboratory of Mechanical Engineering, Sheffield Scientific School, on November 18. The following papers were presented: Electricity in Industry by Prof. Charles F. Scott, and Motor Applications; Arc Welding; Heat Treatment by W. L. Merrill of the General Electric Company. Following the presentation of the papers were a number of short addresses on applications of electricity by local manufacturing companies. The speakers were Mr. Flynn of the Royal Typewriter Company of Hartford on the Use of Electricity in Japanning Kilns, and Charles R. Underhill of the Acme Wire Company, New Haven, on the Use of Electromagnets in Manufacturing. W. S. Huson of Derby and C. H. Norris of New Britain discussed the papers.

Immediately after the afternoon session, there was an interesting demonstration in the laboratory of the variable speed hydraulic transmission manufactured by the Waterbury Tool Company of New Britain. This exhibit was arranged by courtesy of the Yale University Student Branch of the Society. Reynold Janney was in charge of this feature of the meeting.

J. Arnold Norcross was the Chairman of the evening session. Calvin W. Rice, Secretary of the Society, gave a talk on the Society and its work. The principal paper of the session was by S. S. J. Worgan of the Westinghouse Company on The Electric Motor in Manufacturing Plants. Short addresses were made by Prof. Scott, W. N. Polakov of the N. Y., N. H. & H. R.R. Company and Mr. Vandervere of the New Haven Gas Light Company and several others. The registration at the session was 150.

BOSTON, NOVEMBER 18

At a joint meeting of the Society with the Boston Society of Civil Engineers and the American Institute of Electrical Engineers on November 18, Henry M. Waite, city manager of Dayton, Ohio, gave an address on the new Commission-Manager Form of City Government.

He criticized at the outset the older federal form of city organization, and said that before a new system could be introduced the grasp of professional politicians must be loosened and ward and precinct organization relegated to the past. He called attention to the necessary allegiance of the political appointee to his political machine and the popular belief that the mayor and his administration should be blamed for all shortcomings, even though the chief executive were tied hand and foot and shorn of administrative power.

In Dayton, politics and municipal affairs had been divorced. Five commissioners were elected last November, all of whom are business men. This commission appointed a city manager and it is in the manager's power to appoint the five directors of law, finance, welfare, safety and service.

BUFFALO, NOVEMBER 19

At the meeting of the Buffalo Engineering Society on November 19, Prof. Dexter S. Kimball, professor of machine design and construction at Cornell University, addressed the Society on Appearance as a Factor in Design. Professor

Kimball treated his subject along broad lines, free from technicalities. There was an attendance of about 130 at the meeting.

CINCINNATI, NOVEMBER 19

At a joint meeting with the Engineers' Club of Cincinnati on November 19, Fred A. Geier, Associate Member of the Society, spoke on The Development of the Machine Tool Industry in Cincinnati. He traced the begininng of the industry to John Steptoe, who in 1850 built the first machine tool in Cincinnati. To Mr. Steptoe must be given the credit of having laid the foundation of one of the most important industries of Cincinnati, which has placed Ohio first in the production of machine tools. The second firm to install a department of machine tools was that of Niles and Company in 1865. This firm later developed into the Niles Tool Works and moved to Hamilton, Ohio. George Gray of this company remained in Cincinnati, however, and continued the manufacture of planers.

The speaker then outlined the conditions that make Cincinnati a good center for the manufacture and distribution of machine tools. He gave estimates of the volume of business at the present time, the number of men employed and the possibilities of development in the future.

ST. PAUL, NOVEMBER 19

A meeting of the Minnesota Branch of the Society was held at St. Paul on November 19. V H. Roerich, City Chemist presented a paper on Coal Testing. The paper aroused considerable enthusiasm and discussion.

CHICAGO, NOVEMBER 20

The Chicago Section held its first meeting of the season on November 20. There was an informal dinner at which 140 were present. W. H. Winslow, the first speaker, explained the construction and operation of his new high-pressure boiler. He touched upon the possibilities of high pressures and of the Stumpf una-flow engine, which appears to be the prime mover best adapted for high pressure and super heat. His talk was illustrated by lantern slides.

Henry A. Allen, consulting engineer for the City of Chicago, and Robert Cramer, engineer of the Winslow Company, discussed the paper. Mr. Allen believed that the new boiler was specially adapted for portable use, such as for automobile trucks or buses and the large traction plow. Mr. Cramer believed that this boiler would soon be used by the largest power plants of the country and would show results at least 12 per cent higher than the best obtainable today.

The subject of boiler efficiency meters and European boiler practice was presented by W. A. Blouck, maker of the boiler efficiency meter. He explained briefly the principles of his meter with the red and blue fluids showing the drop in draft through the furnace and setting respectively. Mr. Blouck then spoke of European boiler practice. By means of slides, he showed the fine architectural design of the buildings and the efforts made to add to the appearance of the stack. Cross-sectional views showed the design generally followed and the small bunker capacity for coal. The latter was stored on the ground and conveyed to the boiler as needed. The injector draft chimney was in frequent evidence and ash-handling facilities were a negative quantity due largely to cheap labor. Small steam pipes with velocities up to 14,000 ft. per minute were also a feature.

The last part of the talk was devoted to the high-duty boiler with built in economizer. Evaporation tests of this kind of a boiler at Hamburg were presented. Joseph Harrington discussed some of the advantages of the German boiler, but he was of the opinion that the Blouck meter was very accurate and should be of great value in the boiler room.

Walter H. Green, chief engineer of the International Filter Company, spoke on mechanical filters, dwelling on methods of rating and some of the experiences that his company has had with prospective customers. Reference was made to the tendency of installing filters that were too small and also to the matter of using sand or quartz in the filter. Either may be used, but sand may be used in its natural state, whereas quartz must be ground. If sand is used, however, careful attention must be given to the choice of the sand, as it is quite essential that the particles be of uniform size.

PHILADELPHIA, NOVEMBER 21

A joint meeting with the Engineers' Club of Philadelphia was held on November 21. F. C. Hubley, Assistant Engineer of the American Bridge Company, gave a paper on Bituminous Coals; Predetermination of their Clinkering Action by Laboratory Tests. In a search for a specification that would really tell the operating properties of coal, the author discusses the clinkering of coal, which, as he shows, materially affects the capacity and efficiency of the plant, the amount of labor spent in cleaning fires and upkeep of fire boxes, and the smoke generation. The delays due to excessive clinkering may sometimes offset the advantage of a lower price of the coal. In order to specify the clinkering of coal in purchase contracts, however, a clear comprehension of this property has to be worked out, and methods developed for its laboratory determination, and the author shows that the former is possible by determining not the "fusible point" which, with a complex mixture such as coal ash, cannot be well defined, but the "fusible range" which is capable of precise definition and exact determination. He then proceeds to describe various methods of determining the fusing point of ash, such as the cone method, the fusiometer method, etc. He shows also that there is always a point capable of definite recognition in the fusing range, which although not the fusing temperature in the ordinary sense, is nevertheless a stage past that of incipient fusion and that this point of temperature bears a direct relation to the clinkering temperature in a boiler furnace, while the nature of the clinker formed, whether porous or spongious or close and hard, has as much to do with the detrimental effect on boiler operation as the question of temperature of formation. Fusing points were plotted against combination of the ash constituents so as to determine a relation between the approximate fusing point and the presence of two or more of the ash elements as determined by chemical analysis.

This very important subject was discussed by A. C. Wood, Professor Fernald, W. H. Fulweiler, E. M. Nichols, Dr. H. M. Chance, F. C. Freeman, Mr. Clonnell and E. B. Carter.

BUFFALO, DECEMBER 3

Ellis L. Howland addressed the meeting of the Buffalo Engineering Society on December 3, on the subject Practical versus Theoretical Ideals in Motor Truck Installation. Mr. Howland is automobile editor of the *Journal of Commerce* of New York City and he treated his subject from

the users or commercial standpoint and not from an engineering standpoint.

H. B. Alverson of the Cataract Power and Conduit Company and First Vice-President of the Engineering Society of Buffalo was in charge of the meeting. There were about 170 present.

SAN FRANCISCO, DECEMBER 8

At a meeting in San Francisco on December 8, the paper of the evening was read by A. H. Babcock, consulting electrical engineer for the Southern Pacific Company, on A Rational Method for the Treatment of Boiler Feed Water. Mr. Babcock described in detail the remarkable results that had been achieved in the treatment of the boiler feed water used at the Alameda power station for the Southern Pacific Company's suburban trains.

Mr. Geibel, who is Mr. Babcock's assistant and who is in direct charge of the experimental work showed in detail the methods that were pursued in overcoming the corrosive effect of waters carrying a large percentage of alkalinity, and also methods of testing the feed water for determination of the new treatment and the apparatus used for this purpose.

Mr. Twogood and Mr. Partridge also spoke briefly on the subject. The meeting was then open for discussion.

BOSTON, DECEMBER 9

At a local meeting in Boston on December 9, Mr. Nunez gave a paper on the Technology of Paper Making. In this paper, Mr. Nunez traced the different processes in the manufacture of paper and the different materials from which paper has been made from the time when it was first invented by the Chinese to the present time. He then discussed the quality, kinds, consumption and uses of paper. Paper is an extremely important article of commerce and has innumerable uses. The quality of any paper depends upon the use to which it is to be put, but the qualities which have to be considered and which govern its value for use are: strength, bulk, fibre direction, formation, finish, feel, texture, rattle, sizing, opacity, color, printing, erasing qualities, expansion and contraction, fibre composition, chemical residue and durability.

NECROLOGY

EDWARD DANIEL MEIER

In the death of Col. Edward Daniel Meier on Tuesday, December 15, 1914, after several months of illness, the engineering profession has lost one of its most honored members. He was president and chief engineer of the Heine Safety Boiler Company, president of The American Society of Mechanical Engineers in 1911, and for 20 years was one of the most active workers in the Society. He enjoyed an unusually wide circle of friends, as evidenced by the presentation at the Pittsburg meeting of the Society of an engrossed testimonial by a large number of his fellow members in celebration of his seventieth birthday.

He was born in St. Louis, Mo., May 30, 1841. At the close of a scientific course at Washington University, St. Louis, in 1858, he spent four years in Germany at the Royal Polytechnic College in Hanover, this being followed by an apprenticeship at Mason's Locomotive Works, Taunton, N. J. In 1863 he enlisted in the Grey Reserves, the Thirty-Second Pennsylvania, which was attached to the army of the Potomac until after the Battle of Gettysburg. He subsequently served in the Second Massachusetts Battery, also in the United States Engineer Corps, and finally became lieutenant in the First Louisiana Cavalry, seeing much active service, and on May 30, 1865, receiving the surrender of Lieutenant-General John B. Hood and staff.

At the close of the war he entered the Rogers Locomotive Works, at Paterson, N. J., remaining one year. From 1867 to 1870 he was associated with the Kansas Pacific Railway, first as assistant superintendent of machinery, keeping open its Western communications when the bridges were swept away, designing, building and operating a mill for sawing, planing and turning the soft magnesian limestones by machinery, designing machine and car shops, etc., and subsequently becoming superintendent of machinery. He resigned to become chief engineer of the Illinois Patent Coke Company, leaving there in 1872 to assume the secretaryship of the Meier Iron Company and to build its blast furnaces. From 1873 to 1875 he directed the machinery department of the St. Louis Interstate Fair. During this time he became actively interested in the St. Louis cotton industry and was associated with the St. Louis Cotton Factory and with the Peper Hydraulic Cotton Press, for both of which he designed machinery for compressing cotton. In 1884 he organized the Heine Safety Boiler Company for the development in the United States of the water-tube boiler of that name, and continued as its president and chief engineer to the time of his death. He was also responsible for the introduction of the Diesel motor into the United States and until 1908 was engineer-in-chief and treasurer of the American Diesel Engine Company. One of his most important accomplishments was the design and installation of 10,000 h.p. boilers in the power house of the new Grand Central Terminal, New York.

Colonel Meier was lieutenant-colonel and later colonel of the First Regiment of the Missouri National Guard, serving about ten years, and was a member of the Grand Army of the Republic and of the Loyal Legion. He had been active in a number of professional organizations, serving in 1881-1884 as treasurer of the St. Louis Engineer's Club, in 1889-1890 as its president, and as secretary of the American Boiler Manufacturers Association. It was in the latter capacity that he drew up the Uniform American Boiler Specifications of 1898. He had been president of that organization and also of the Machinery and Metal Trades Association.

In The American Society of Mechanical Engineers, which he joined in 1891, he was active on many committees. He served as manager from 1895 to 1898, twice as Vice-President, from 1898 to 1900 and from 1909 to 1910, and as President in 1911. At the time of his death he was a member of the committee of the Society to formulate Standard Specifications for Steam Boilers, which had its inception largely through his efforts and which has accomplished a vast amount of work during the past three years.

A source of the greatest satisfaction to Colonel Meier, and a delightful memory to his many friends, was his connection with the remarkable tour through Germany in the summer of 1913 at the invitation of the Verein deutscher Ingenieure. Colonel Meier was chairman of the committee hav-

ing all the arrangements in charge, to a considerable extent was conductor of the party and many times was its spokesman. He often addressed his audience in German and his intimate knowledge of German history and accomplishment and his thorough appreciation of the industrial ideals of the nation added materially to the value and pleasure of the trip to the large number of engineers and guests who constituted the party.

AXEL H. HELANDER

Axel H. Helander was born in Vingaken, Sweden, in 1864, but came to America as a boy and spent most of his life in Pittsburgh. From July 1, 1906, to September 30, 1912, Mr. Helander was connected with the engineering department of the Mesta Machine Company after which he was with the William Tod Company, of Youngstown, Ohio, as second vice-president and general sales manager. Mr. Helander was the designer and inventor of many important engineering devices, chief among which might be listed the Helander condenser. He died at his home in Youngstown on October 17.

PERSONALS

Jay G. DeRemer has accepted a position with the American District Steam Company, North Tonawanda, N. Y. He was until recently affiliated with the United Light and Power Company, San Francisco, Cal., as chief engineer.

Ruland R. Shafter has accepted a position with the Chester Steel Castings Company as their New York manager.

Julius G. Berger has become connected with the Fulton Light, Heat and Power Company, Fulton, N. Y., as engineer.

Nicholas S. Hill, Jr., consulting engineer, has formed a partnership with Smith Farley Ferguson, and will continue to practice with him as a consulting hydraulic and sanitary engineer, under the firm name of Nicholas S. Hill, Jr., and S. F. Ferguson.

M. C. Maxwell, for the past seven years head of the Department of Applied Mechanics at Pratt Institute, Brooklyn, N. Y., and a Consulting Engineer, became identified with the Yale and Towne Manufacturing Company of Stamford, Conn., on July 1, 1914. He is now Superintendent of Power and Plant of that company, and is responsible for the power generation and distribution, the building maintenance, all new building construction, the general repairs and maintenence of all machinery, shafting, etc., throughout the plant. He also has charge of the tool department and is responsible for all tool designing, the machine shops for building tools, jigs, fixtures, dies, gages, etc., and the forge shop.

E. L. Hill has recently accepted a position with the Hazard Manufacturing Company at Wilkesbarre, Pa., in the capacity of Consulting Engineer and assistant to the Management. He was formerly with the American Steel and Wire Company, and for the past four years was superintendent of the company's insulated wire and power cable plant at Worcester, Mass.

Daniel W. Mead, having been absent from the United States during the summer as a member of the American National Red Cross Board of Engineers-Chinese River Conservancy, wishes to announce that he has returned, and is now prepared to serve his clients in making examinations, reports, plans and specifications for water power, water supply, flood protection, drainage irrigation, power plants and power transmission installations.

Dr. George F. Swain, Professor of Civil Engineering at Harvard University, delivered a lecture on Laws Hamper Improvement of Resources before the Technology Club of Syracuse on December 2. This was one of the series of lectures by prominent men which are called the "John E. Sweet Lectures" in honor of the Club's first President.

J. H. Dougherty, formerly with the International Steam Pump Company, has been engaged by the Northern Equipment Company to take charge of the centrifugal pump design and the improvement and development of the well-known line of Erie Centrifugals.

Prof. C. R. Richards, Acting Dean and Director of the College of Engineering and Experiment Station of the University of Illinois, announces that there will be four vacancies for research fellowships to be filled at the close of the current academic year. These fellowships, for each of which there is an annual stipend of $500, are open to graduates of approved American and foreign universities and technical schools. Appointments to these fellowships are made and must be accepted for two consecutive collegiate years, at the expiration of which period, if all requirements have been met, the Master's degree will be granted. Not more than half of the time of the Research Fellows is required in connection with the work of the Department, the remainder of the time being available for graduate study. Applications must be made not later than February 1 to the Director of the Station. Appointments are made in March and they take effect the first day of the following September.

Leo Loeb has been transferred from the Engineering Experiment Station at Annapolis, Md., to the Post Graduate Department of the United States Naval Academy at Annapolis, as professor of marine engineering.

Anderson Polk announces the opening of an office as testing and inspecting engineer, specializing in protective coatings and paint problems, with facilities for testing and analyzing cement, brick, iron, steel, paints and varnishes, waterproofing and all building construction materials.

James E. Allison, Chief Engineer of the St. Louis Public Service Commission, has been appointed as lecturer in Economies at Washington University. The lectures will deal with the economic principles underlying the regulation of public utilities. Some of the specific problems to be studied are the organization and operation of public utility corporations, their securities and the methods of financing them, and especially the method of valuing public utility properties for the purpose of taxation and rate regulation. Seniors in the Engineering School will be required to take this course. In order to encourage further the study of economics by the students, Mr. Allison has established a fund to be known as the "Allison Fund," the annual income of which is to be used either for awarding cash prizes or in such manner as in the opinion of the Dean of the School of Engineering and the head of the Department of Economics will best promote the object of the fund.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

On December 2, the Armour Institute of Technology Student Branch held its third meeting. Frederick Purdy, factory engineer for the Rayfield Carburetor Company gave a talk on Carburetion. Starting with the primitive carburetor of the surface type, Mr. Purdy showed the advance that has taken place by means of working models and slides. A number of curves from carburetor tests served to show the effect of various adjustments on the carburetor.

CARNEGIE INSTITUTE OF TECHNOLOGY

The regular monthly meeting of the Carnegie Institute of Technology Student Branch was held on November 11. After the regular meeting, the Mechanical and the Mho Clubs were jointly addressed by Mr. Hood of the mechanical engineering department of the Bureau of Mines. In a short time, the Bureau which will coöperate closely with the Institute in its work, expects to open its new buildings near the school.

In these buildings, will be located a mining, a mechanical engineering, a chemical, a miscellaneous mineral, a petroleum and an administrative department. In outlining the work of the Bureau, Mr. Hood said: "It shall conduct inquiries and scientific and technologic investigations concerning mining and preparation, treatment, and utilization of mineral substances with a view to improving health conditions and increasing safety, efficiency, economic development and conserving resources through the prevention of waste in the mining, quarrying, metallurgical, and other mineral industries; to investigate explosives and peat; and on behalf of the government to investigate the mineral fuels and unfinished mineral products belonging to, or for the use of the United States, with a view to their most efficient mining preparation, treatment and use; and to disseminate information concerning these subjects."

CASE SCHOOL OF APPLIED SCIENCE

At a meeting of the Student Branch of the Case School of Applied Science, a paper was presented by A. P. Armington, '15, on Efficiency Engineering. Three methods were taken up in detail and illustrated by examples: 1. Direct office control of production; 2. Time keeping with use of lapse time recorders; 3. Piece work systems and method of calculating rates. A discussion followed the presentation of the paper.

COLUMBIA UNIVERSITY

At a meeting of the Columbia University Student Branch on November 23, Prof. C. E. Lucke gave a lecture on Surface Combustion explaining its theory and design problem and showing the commercial advantage of this process of heating.

At a meeting on December 11, Arthur V. Fair of the S. F. K. Ball Bearing Company gave an interesting lecture on the Present Day Application of Ball Bearings. He spoke of the method of manufacturing and assembling ball bearings, their lubrication and care, the method of mounting them and their application to numerous industries such as the textile, machine tool, motor, locomotive, steel car, steel mill and automobile.

CORNELL UNIVERSITY

A meeting of the Student Branch of Cornell University was held on November 18. Prof. R. C. Carpenter spoke on the necessity for research in making possible the practical application of scientific theories and knowledge and the need of the college not for the spirit of research but for equipment upon which that spirit might work for beneficent end.

Prof. A. W. Smith, Dean of the College, spoke informally on the founding and ideals of the Am. Soc. M.E. and the mutual benefits enjoyed by the Society and its members.

At a meeting on December 16, Prof. D. S. Kimball lectured on primitive and recent mining machinery and methods. He spoke in particular of those in use in the development of the deep mines at Virginia City, Nev.

KANSAS STATE AGRICULTURAL COLLEGE

At a meeting of the Kansas State Agricultural College Student Branch on November 3, Professor Schluss gave an interesting paper in which he discussed some of the problems met with in the design of governors and the operation of different types of governors. Floyd Pattison, a graduate student, discussed the operation and manufacture of gas producers and emphasized many of the operation troubles of a producer gas plant.

At a meeting held December 3, Mr. Hinman of the apprentice department of the Santa Fe Railway System discussed the efficiency movement and the wide field where efficiency could be practiced. Mr. Hinman discussed in detail the necessity of coöperation of all employees for the best results and the advantages and disadvantages of day wages, piece work and the bonus system. In conclusion, he gave an outline of the apprentice school and its advantages to the men in the shops and to the employer.

W. W. Haggard, a student, read a paper which gave a detailed description of the Dynamometer Car used by the Santa Fe Railway, the chronograph and records, and the way these records were taken and worked up by the office force.

LEHIGH UNIVERSITY

On November 10, the Student Branch of Lehigh University held a meeting at which the following papers were read: A Summer in the British Isles by D. Davidson '15 and Mechanical Engineering of Anthracite Coal Mines by W. H. Lesser, mechanical engineer for the Philadelphia and Reading Coal and Iron Company at Pottsville, Pa.

LELAND STANFORD JR. UNIVERSITY

At a meeting of the Leland Stanford Jr. University Student Branch on November 12, G. W. Dickie, Consulting Naval Engineer in San Francisco delivered a lecture on Safety at Sea. Mr. Dickie laid great emphasis on the importance of stability in steamship design.

OHIO STATE UNIVERSITY

On November 13, Edward P. Roberts, M.E. of the Roberts and Abbott Company, Consulting Engineers, Cleveland, Ohio, also Smoke Commissioner in the Department of Public Safety of that city, addressed the members of the student branches of the A.S.M.E. and the A.I.E.E. on the subject of Smoke Abatement.

Mr. Roberts discussed the various types of boiler settings for both the water tube and fire tube boiler and showed several arrangements that he had found to be very successful and comparatively cheap to install. He stated, however, that a setting which might give very complete and smokeless combustion under one set of conditions, might be wholly unsatisfactory if used under slightly different conditions, and emphasized the point that each case had to be dealt with separately. He named the requisites for complete combustion and then showed how the designers of the various types of stokers upon the market today had endeavored to make their stoker embody these principles.

The speaker gave figures showing the enormous losses which Cleveland and Pittsburgh attributed to the smoke nuisance, Cleveland's loss according to the 1908 report being \$6,000,000 or \$44 per family. This does not include the loss to plant and animal life, or the effect upon the respiratory organs of the people. He explained the methods used by the smoke inspectors of Cleveland in finding the offenders and the methods used in dealing with them, also the results of their work showing the great improvement they had effected in the abatement of the smoke from railway and yard locomotives. Mr. Roberts stated that the abatement of smoke was a problem well worth considering by all large cities, both from an economic and engineering standpoint. He claimed that the Cleveland department was paying several thousand per cent on the money invested in it.

The lecture was illustrated by lantern slides.

At a meeting on December 15, S. J. Lauer presented a paper on A Comparison of the Six-cylinder versus the Eight-cylinder Motor Car Motor. H. S. Vine gave a paper on The Oxy-acetylene Process of Welding. There was no discussion.

STEVENS INSTITUTE OF TECHNOLOGY

The Student Branch of Stevens Institute of Technology held its first lecture for the school year on December 8. Prof. William Kent, an alumnus of Stevens, a member of the American Society of Mechanical Engineers and a compiler of the well-known Handbook for mechanical engineers, gave a very interesting talk on Common Sense and Engineering, illustrating his subject with numerous appropriate stories. The meeting was especially honored by having two other prominent men in the American Society of Mechanical Engineers and in the engineering world, as speakers. Dr. Humphreys, President of Stevens Institute of Technology, gave a short prelude to the lecture by speaking of the engineer's place in the business world, while C. W. Rice, Secretary of the American Society of Mechanical Engineers, said a few

words on the Society's branches among students and the way in which they could be strengthened.

THROOP COLLEGE OF TECHNOLOGY

The first regular meeting of the Throop College of Technology Student Branch was held on December 18. C. H. McQuire, representative of the Los Angeles Branch of the Busch Sulzer Diesel Engine Company, spoke on the Diesel Engine. Lantern slides were used to illustrate his talk.

UNIVERSITY OF CINCINNATI

The University of Cincinnati Student Branch held a meeting on November 28, at which D. J. Durrell, master mechanic of the Pennsylvania Railroad, gave a talk on the duties of the mechanical engineer, what conditions a mechanical engineer must face upon graduation, railroad work as applied to mechanical engineering and some of Mr. Durrell's experiences in that profession The first two points the speaker discussed in detail and in the discussion of the third point, he included a brief history of the locomotive regarding its weight and its ability to devour space, also a summary of the transportation units and the traffic of the Pennsylvania Railroad during the year 1913-1914.

Prof. J. T. Faig, honorary chairman of the student branch, gave a short extemporaneous talk in which he pointed out the analogy of some of the speaker's remarks and his own teachings.

UNIVERSITY OF COLORADO

A meeting of the University of Colorado Student Branch was held on December 10. Charles M. Hampson, a consulting engineer from Colorado and a member of the Am Soc. M. E., delivered a lecture to the students on the ethical side of engineering, or as he said that he liked to call it, the "side of the square deal." In tracing the growth of the profession, he showed that the responsibilities of the mechanical engineer of today are much greater than those of the mechanical engineer in the earlier days of the profession.

UNIVERSITY OF KENTUCKY

The first regular meeting of the University of Kentucky Student Branch was held on November 28, at which the following officers were elected: Minott Brooke, president; Y. B. Arnold, vice-president; P. T. Taylor, treasurer, and T. R. Munson, secretary.

Prof. F. P. Anderson, Dean of the College of Mechanical and Electrical Engineering, spoke on the relation of the branch with The American Society of Mechanical Engineers and the advantages of the young engineer by belonging to the Society.

On November 4, Dr. A. S. McKensie, Dean of the Graduate School, spoke to the branch on the value of research work to the engineer.

UNIVERSITY OF MAINE

At a meeting of the University of Maine Student Branch on December 17, four reels of moving pictures which belonged to the National Tube Company showed the ore as it was taken from the mines in the Lake Superior region, its transportation to the company's factories and the different processes through which it goes before it finally becomes the tube product.

UNIVERSITY OF MICHIGAN

A meeting of the University of Michigan Student Branch was held on December 5. F. R. Still of the American Blower Company gave a short talk on The Application of Blowers to General Engineering Practice which included the ventilation of public buildings, the necessity of humidifying the air in such buildings for the health of the inhabitants, a process of air drying which is being tried in the west on some of the fruits instead of the regular sun drying, and a continuous process for manufacturing of bricks which has proved successful on a great many kinds of brick.

Mr. Still showed slides illustrating different types of blowers and their various applications, also some curves from which these fans are designed to meet the requirements.

UNIVERSITY OF MINNESOTA

At the November meeting of the Student Branch of the University of Minnesota, Prof. C. F. Shoop of the Department of Experimental Engineering was selected to Honorary Membership.

Messrs. C. J. Snow and E. H. Roberts presented papers on the Heating and Ventilating of the New Saxe and Shubert Theaters. The Saxe Theater, a motion picture house with a seating capacity of 1400 is heated and ventilated by the plenum system. The fresh air is taken in at the roof level, and taken down a vertical shaft from which it passes through the temperature coils which consist of 918 sq. ft. of "Vento" heaters, arranged two stacks deep and two tiers high. It next passes through the air washer which is of the "Webster" make, and from there through the re-heating coils which consist of 1836 sq. ft. of "Vento" heaters arranged four stacks deep and two tiers high. The air is then drawn through the fan and from there is sent to the distributing branches. The building is provided with automatic temperature and humidity control, making the plant entirely automatic. Steam is purchased from an outside source at the rate of $.55 per 1000 lb. of condensate.

The Shubert Theater heating plant consists of a low pressure steam heating plant and plenum system of ventilation. The heating system consists of 66 ft. by 16 in. tubular boiler, on a two pipe steam system with 560 sq. ft. direct radiation. The ventilating system consists of a 60 in. steel plate fan, directly connected with a 10 h.p. motor running at 250 r.p.m. Air is drawn from street level through a bank of coils containing approximately 4000 lineal ft. of 1 in. pipe, which is equivalent to 1561 sq. ft., having free area of 23.1 sq. ft. Air is discharged into a large plenum chamber extending under the greater part of the auditorium. From here it goes directly into the auditorium through about 400-9 in. by 6 in. openings with hoods, so that the discharge is parallel to the floor. Exhaust is by means of natural draft. The peculiarities of the plant are that the air velocity is reduced both in coils and chamber, and dust is thus eliminated without special apparatus. The efficiency figured on a B.t.u. basis is 67 per cent, exclusive of boiler.

At the December meeting of the branch, M. E. Crosby gave a general outline of the flour industry. He traced the wheat through the different processes which it undergoes from the time it enters the mill until it is turned out as one or more different grades of flour.

In conjunction with Mr. Crosby's talk, A. P. Mason gave a description of a grinding machine which is used to grind screenings. The principal feature of this machine is a perforated cylinder of hardened steel against which the stock is thrown tangentially at the high velocity. A shearing effect is thus produced which reduces the stock to the desired size.

UNIVERSITY OF MISSOURI

At a meeting of the University of Missouri Student Branch on December 3, Messrs. Haney and Royse were appointed to investigate affairs pertaining to the society's proposed inspection trips to St. Louis, Mo., and other nearby cities.

Ralph Coatsworth read a paper on the new 8 cylinder "V" type internal combustion motor which is now used by the Cadillac Motor Company.

UNIVERSITY OF NEBRASKA

At a meeting of the University of Nebraska Student Branch on December 1, Prof. B. F. Raber of the Department of Mechanical Engineering who spent the summer in the turbine department of the Westinghouse manufacturing plant at Pittsburgh, Pa., gave an illustrated lecture on the Pittsburgh District.

The town proper is located at the point which is formed by the junction of the Allegheny and Monongahela Rivers, and the district includes the area within a radius of about forty miles of this point. The country is very hilly and the flood plains of the rivers are bordered by high cliffs. On account of the rugged nature of the country, the district is divided into an enormous number of small towns and cities.

The mills that are scattered through the country and along the rivers together with their employees form towns by themselves. One of the largest of these outside of Pittsburgh proper is Wilkinsburg, where most of the Westinghouse employees make their homes. It has a population of about 20,000. Other large and thickly populated parts are So. Pittsburgh which is across the Monongahela River from the Point and Allegheny which is across the Allegheny River from the Pittsburgh District. The population of the Pittsburgh District is over 4,000,000.

Professor Raber gave views of Pittsburgh showing the business and residence districts, wharves, private residences, parks and the buildings of the University, including the exterior and interior of the Carnegie Institute and School of Technology. He showed some views of places outside of Pittsburgh proper which included all of the larger steel and iron mills, the plants of the American Signal Company and the Westinghouse Company. He described their products, the number of employees and the pay roll. The turbines and engines of the Westinghouse type were shown both complete and in course of construction. One of these was being built for the U. S. S. "Neptune."

WORCESTER POLYTECHNIC INSTITUTE

At the meeting of the Worcester Polytechnic Institute Student Branch on December 4, H. Clayton Kendall of the Rockwood Sprinkler Company gave an illustrated lecture on Factory Fire Protection. After a brief review of the amount of property loss by fire, the speaker described the mechanical means taken to put water on a fire in its incipient stage. The foremost mechanical device at the present time for doing this according to Mr. Kendall is an automatic sprinkler head kept properly supplied with pressure water. In the lantern slides shown by Mr. Kendall, the effect of an automatic sprinkler system as preventing serious conflagrations in buildings thus equipped was clearly presented.

YALE UNIVERSITY

A meeting of the Yale University Student Branch was held on November 13. At this meeting, Reynold Janney, Vice-President and Chief Engineer of the Waterbury Tool Company, presented an illustrated paper on the Hydraulic Variable Speed Gear manufactured by the company with which Mr. Janney is connected. Mr. Janney's address was divided into three parts as follows: a. the advantages or practical aspect; b. the mechanical construction; c. the mathematical problems connected with the gear.

After the lecture, Mr. Janney demonstrated one of the gears which was mounted, together with its motor as a single unit.

EMPLOYMENT BULLETIN

Note: In sending applications stamps should be enclosed for forwarding.

The Secretary considers it a special obligation and pleasant duty to be the medium of securing positions for members, and is pleased to receive requests both for positions and for men. The published notices of "men available" are made up from members of the Society. Notices are not repeated except upon special request. Names and records are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month.

POSITIONS AVAILABLE

1201 Representatives wanted in the principal cities of United States to sell vacuum heating specialties on commission. Apply through Society. Applicant will please state what similar specialties, if any, he has previously sold.

1202 Several good draftsmen—salaries $100 to $125 per month. Location South Bethlehem, Pa.

1203 Superintendent and master mechanic, man of refinement, preferably graduate of M.I.T., with textile mill experience, and one who can take a position of prominence in company and city. Salary about $2500. Age 30 to 35. Apply through Society.

1204 New England University desires assistant to the instructor in charge of the mechanical laboratory and in correcting of problems in thermodynamics, mechanism, and machine design. Desires a man with initiative and a desire to make good.

1206 Assistant in the boiler insurance department of a casualty and surety company; salary $1200 per year to start with reasonable expectation of steady advancement; essential requirements, knowledge of engines and boilers and ability to conduct correspondence. Young man preferred. Location New York City. Apply through Society.

1239 Man capable of taking charge of the production of a manufacturing department; requires experience in stamping, drawing and forming of steel; other desirable qualifications are ability to meet men in trade and to estimate orders and handle correspondence. Location Connecticut. Apply through Society.

1253 High class man to represent a Michigan company in the City of New York; must show a splendid record in the selling end of the power plant field, have a thorough acquaintance with the consulting engineering profession and must be a high-class salesman in the full sense of the word. Apply through Society.

1254 Competent young man to fill the position of assistant superintendent in a shop where a variety of heavy machinery is manufactured. Name confidential. Apply through Society.

01 Two competent detail draftsmen, experience in sugar house work; must be rapid and accurate. Location New York. Apply through Society.

02 A good opening for an engineer thoroughly experienced in design and operation of hot bulb two-cycle oil engines. Should be familiar with both foreign and domestic practice. Location, Illinois. Apply through Society.

04 Large New Jersey plant wants a technical graduate, not over 30 years of age, to serve an apprenticeship and learn the technical and executive business of an important department, with a view, if successful, of becoming assistant superintendent. Give full statement of record, accounting for all of time since leaving college. Starting salary, $25.00.

07 Chief Draftsman, high grade practical machine designer, experienced in machine, pattern shop and drawing room; must be a man who can make practical designs from a shop standpoint, that goods may be manufactured cheaply and be of such grade as to meet the best competition. Position permanent for man of ability. Location, Missouri.

08 Young shop superintendent and engineer, one who has had considerable experience and is thoroughly familiar with machine work, and can also take charge of the drafting room, with ability to cut down manufacturing costs. Location, Illinois. Apply through Society.

MEN AVAILABLE

A-1 Junior member, age 25, experienced in factory work, machinist, tool and die-maker, designing of tools, machines, mill buildings, power plants and their equipment, also reports, factory accounting and reorganization, desires position in charge of production or in engineering department.

A-2 Mechanical engineer 1914 graduate with new untried idea for kerosene carburetor, desires position in experimental department of gas engine company willing to try out his idea.

A-3 Member, graduate engineer, experience as efficiency engineer, also design and supervision of installation of mechanical equipment of buildings, power plants and central heating systems, desires position with consulting engineer, architect or private concern.

A-4 Member, age 35, technical graduate, ten years experience in civil, mining and mechanical engineering, steel plant and general construction work desires executive or

sales position where broad experience, energy and tact will be required with good chance for advancement. At present employed.

A-5 Technical gradaute, Junior member, age 25, three and one-half years practical experience in engineering, desires position in selling department of manufacturing concern. At present employed in New York.

A-6 Associate, age 43, with wide manufacturing and considerable commercial experience would consider a position of responsibility in a large manufacturing concern or power company, or the general managership of a small growing company with good possibilities.

A-7 Member, graduate mechanical engineer, 20 years experience as designer and draftsman of simplex and duplex steam pumps, desires position as designer or chief draftsman.

A-8 Junior member, M.E., technical graduate, age 27, married, three years experience in drafting, machine design and laying out of hydro-electric plants, desires position with opportunity for experience and advancement. Location immaterial. At present employed.

A-9 Member, age 34, M.I.T. graduate, married, for past six years with leading engineers and architects in the East, designing steam power plants, heating and other piping systems and inspecting constructions and equipment, at present employed as superintendent on construction and equipment of large mill and power plant, desires position along similar lines.

A-10 Technical graduate, age 32, nine years experience in mechanical department of large western railroads as chief draftsman and mechanical engineer, three years as construction engineer and superintendent on power plant and shop construction. Has specialized in crude oil burning arrangements as applicable to locomotives and stationary boilers, shop, and power plant design, construction and equipment and electrical installations. Speaks Spanish; would consider foreign location.

A-11 Member, technical graduate, with commercial training, speaking five languages, fully conversant with Latin and South American trade conditions, 18 years varied experience in design and construction of machinery and buildings, remodeling, maintenance and operation of industrial plants and equipment; systematizing of shops and processes along scientific management lines, testing and general plant engineering; familiar with handling men, drawing up contracts, purchasing equipment and material, appraising properties, modern methods of manufacturing and marketing products, desires to become identified with manufacturing or industrial plant in responsible administrative or executive position. At present employed.

A-12 Member, wide experience in design and construction of factory buildings and power plants, purchasing of supplies and equipment for economical production, designing of special tools and machinery, has held positions as manufacturing superintendent, shop manager and chief engineer for large corporations, desires position with manufacturing or contracting company or firm of consulting engineers.

A-13 Associate-Member, engineering graduate, two years teaching experience, now employed as Diesel engine designer, wishes position of responsibility with manufacturers of oil or gas engines. Eastern location preferred.

A-14 Member, graduate of Stevens '97, broad experience in machine shop practice, superintendent of construction, field work, test of prime movers, boilers and power house design; for many years with leading consulting engineers and contractors in New York as designing engineer and draftsman, desires position of similar nature with engineering firm.

A-15 Engineer with experience in design and construction of special metal working machinery and tools for economic manufacture can offer an improved design of power punching and stamping presses in several sizes.

A-16 Member, Cornell graduate, mechanical and electrical engineer with extensive training and experience in designing, constructing, maintaining, operating and managing, desires a position as mechanical, electrical, efficiency or office engineer, superintendent, manager or purchasing agent of an engineering corporation.

A-17 Member of Society experienced in employment methods will take entire charge for large corporation hiring employees and supervising personal efficiency methods.

A-18 Member, Cornell graduate, fourteen years experience as machinist, material inspector, testing engineer, draftsman, mechanical engineer and salesman, desires position as sales engineer or engineering of tests. Location immaterial, western states preferred. At present employed as salesman of power plant machinery.

A-19 Mechanical engineer, Stevens graduate, age 30, married, six and one-half years varied experience, specialized in pressed steel, both light and heavy, at present holding responsible executive position as plant engineeer with small manufacturing concern, desires a position along similar lines, or one as assistant to superintendent or manager with company offering good chances for advancement.

A-20 Designing and contracting engineer desires to increase his clientele among concerns in need of engineering service in the field of machinery for the expeditious handling of materials of which he has made a specialty.

A-21 Junior, age 31, married, with 12 years experience in heating, ventilating and machine design, estimating, selling, complete knowledge of shop and office methods, capable of taking charge of designs and specifications wishes position with concern where efforts and loyalty are appreciated.

A-22 Member, M.I.T. graduate in mechanical engineering with post-graduate course in electrical engineering, twenty years experience in design and construction of machinery and building, manufacturing, systematizing, accounting, refrigeration and as consulting engineer, desires permanent position in New York.

A-23 Graduate mechanical engineer experienced in drafting, machine shop, foundry work and as a salesman, desires position with manufacturing concern in any department where there is opportunity for advancement.

A-24 Member, experienced in designing of locomotives and cars, specialized in efficiency work and the handling of men, expert examinations of property, desires position as manager of large manufacturing business.

A-25 Student member, age 23, technical graduate with shop and drafting experience, desires position.

A-26 Junior technical graduate in mechanical and electrical engineering, 12 years experience in design, construction, maintenance and operation of power houses and substations, high voltage transmission lines, design and erection of steam and water piping layouts, wiring and installation of machinery, pumps, engines, etc., desires position with large firm. Location New York. Salary $40.

A-27 Junior, graduate mechanical engineer with varied experience desires position with concern manufacturing or selling automobiles or automobile accessories. Willing to start as a demonstrator. Speaks German. Location immaterial.

A-28 Associate, age 40, Lehigh University graduate in mechanical engineering, 18 years experience in mechanical, civil and electrical work, including design, construction and operation of power plants, electric railway track work, industrial buildings, handling correspondence, purchasing, etc., for past seven years in responsible charge of work, wishes executive position of responsibility. Now temporarily employed.

A-29 Member, technical graduate, 16 years railroad experience in motive power department, including shops and

drafting room and mechanical engineering, desires similar position or one as assistant superintendent of motive power. Location immaterial.

A-30 Graduate mechanical engineer, three years practical experience in shop work, design, superintending, cost and sales work, and as head draftsman in engine and boiler works and shop superintendent in gasolene motor works. Moderate salary, location immaterial.

A-31 Junior, technical graduate in mechanical engineering, age 30, five years experience in mechanical and construction work, desires responsible position with manufacturing or construction firm.

A-32 Graduate mechanical engineer, four years practical experience desires position with manufacturing, engineering, contracting or consulting firm. Good future rather than salary considered.

A-33 Superintendent experienced in modern shop and manufacturing practice, good organizer who can produce interchangeable work at low cost and who understands cost keeping and the various systems of paying for labor.

A-34 Associate-Member having organization with several engineers, desires additional Chicago agencies in lines usually referred to architects and consulting engineers.

A-35 M.I.T. graduate in mechanical engineering, single, having specialized in the manufacture of raw and white sugar in the tropics; thorough knowledge of Spanish and tropical business methods. Now employed as chief engineer of large sugar house in the tropics.

A-36 Member, graduate M.I.T. in mechanical engineering, age 39, married, experienced in manufacture of ordnance-rifled arms, shell and ammunition, design and construction of dry docks—wood, stone and floating, pumping plants, power houses, and shops; acid and electrolytic refineries; wire and cable plants; reinforced concrete and general building construction with complete electrical and mechanical equipment for same; nine years general and seven years consulting engineering; position to be executive, superintendent or engineer of construction. Location preferred, Eastern Canada.

A-37 Mechanical and electrical engineer, with a number of years experience in installation and operation of power plant and factory equipments, building construction and maintenance of factories and buildings, is qualified by experience to serve as construction or operating engineer, superintendent of manufacture, or appraisal of power and manufacturing equipment. Permanent position desired, but will not refuse reasonable offer for temporary work.

A-38 Energetic young man, age 26, graduate M.E., three years experience, desires position in mechanical engineering line. Location immaterial.

A-39 Junior member, age 26, experienced in design, construction and operation of steam engines, boilers, refrigerating machinery and power plant accessories, recently employed on design of Panama Canal coaling stations, desires position.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary of Am. Soc. M. E.

American Bureau of Shipping. Rules for Building and Classing Vessels. *New York, 1914.* Gift of American Bureau of Shipping.

American Institute of Chemical Engineers. Transactions, vol, 1913. *New York, 1914.* Gift of Institute.

American Society of Mechanical Engineers. Report (preliminary) of the Special Committee on the Construction of Steam Boilers and for their care in service.

——— Recommendations for a Model Engineers' and Firemen's License Law, a Model Boiler Inspection Law, and a Code of Practical Boiler Rules.

——— Recommendations of the Boiler Code Committee for a Model Stationary Boiler Inspection law, a Model Stationary Engineers' and Firemen's License law, and a code of practical rules. (Progress Report.) Gift of A.S.M.E.

American Trade Index, 1911-13. Domestic edition. *New York, 1913.* Gift of A.S.M.E.

Baylor University. Annual Report of the President and Trustees, 1913-14. *Waco, Texas, 1914.* Gift of University.

Cambridge (Mass.) Water Board. Annual Report, April 1, 1913-April 1, 1914. *Cambridge, 1914.* Gift of Cambridge Water Board.

City Officials of the United States, 1914. Compiled by Engineering News. Gift of A.S.M.E.

Edwards's 900 Examination Questions and Answers for Engineers and Firemen. *Philadelphia, 1912.*

Elementary Electricity and Magnetism, Wm. S. Franklin and Barry Macnutt. *New York, The Macmillan Co., 1914.* Gift of Publishers.

An elementary textbook for schools of technology and colleges. Remarkably clear in language. W. P. C.

Filters and Filter Presses for the Separation of Liquids and Solids, from the German of F. A. Bühler. *London, 1914.*

Forms used in connection with Ohio Electric Light Companies. Gift of L. B. Webster.

Hawaiian Volcano Observatory of the Massachusetts Institute of Technology. Report January-March 1912.

——— Special Bulletin, An address delivered at a meeting December 11, 1913, by T. A. Jaggar, Jr. 1913.

——— Weekly Bulletin, vol. 2, nos. 1-25, 1914. Gift of Massachusetts Institute of Technology.

Hydraulic Turbines, R. L. Daugherty. ed. 2. *New York, 1914.*

Institution of Mechanical Engineers. General Index to Proceedings, 1901-1910. *London.* Gift of J. Inman Emery.

The Kelvin Lecture, S. P. Thompson. Delivered April 30, 1908. Gift of C. W. Rice.

Machine Design, Construction and Drawing, H. J. Spooner. ed. 3. *New York, 1913.*

Materials of Machines, Albert W. Smith. ed. 2. *New York, 1914.*

Mechanisms of Steam Engines, Walter H. James and Myron W. Dole. *New York, J. Wiley & Sons, 1914. Gift of Publishers.*

An elementary treatise on the kinematics of the steam engine for use by students. W. P. C.

Modern Factory, Geo. M. Price. *New York, 1914.*

Motorcycles, side cars and cycle cars, Victor W. Page. *New York, 1914.*

The Most Important Question of the Age; is the efficiency of a thermodynamic reversible cycle independent of the working medium, J. T. Wainwright. *Chicago, 1914.* Gift of author.

The Naval Constructor, George Simpson. A vade mecum of ship design. ed. 3. D. Van Nostrand Co., *New York, 1914.* Gift of Publishers.

This is the third edition of the author's work. It is replete with information of use to the naval constructor and contains much material which might be of great value to any engineer engaged in construction. The author has compiled much out-of-the-way information. W. P. C.

Niagara. State Reservation Commission. 30th Annual Report, 1912-13. *Albany, 1914.*

——— A History, by Chas. M. Dow. *Albany, 1914.* Gift of Commissioners of the State Reservation at Niagara.

Simeon North, First Official Pistol Maker of the United States, S. N. D. North and Ralph H. North. A Memoir. The Rumford Press, *Concord, N. H., 1913.* Gift of S. N. D. North.

Such monographs as this are too few in the United States; the majority of our people are too busy to make historical researches. Mr. North's record is very interesting, as bearing on the history of early American manufacturing. The Librarian wishes to thank the authors for this important contribution to a subject which has not received the attention it deserves. W. P. C.

Ohio Gas Light Association. Question Box. 19-22d Annual Convention, 1903-06. Gift of C. W. Rice.

Oil, Paint and Drug Reporter. Green Book for Buyers. September 1914 edition. *New York, 1914.* Gift of Oil, Paint & Drug Reporter.

Polyphase Currents, Alfred Still. ed. 2. *New York, The Macmillan Co., 1914.* Gift of publishers.

This is the second edition, largely rewritten and rearranged. W. P. C.

Practical Treatise on Milling and Milling Machines. *Providence, Brown & Sharpe Mfg. Co., 1914.* Gift of Publishers.

Published, not as a trade catalogue, but with the idea of presenting such information on the care and use of these machines as will be of assistance to beginners and practical men. There are extensive tables. W. P. C.

Primer of Scientific Management, Frank B. Gilbreth. *New York, 1914.* ed. 2. Gift of author.

The new edition is issued a little more than two years after the old one, showing a constant demand for an elementary treatise on the subject. W. P. C.

Pumping by Compressed Air, E. M. Ivens. *New York, 1914.*

Recall of Judges and Recall of Judicial Decisions. A discussion at the annual meeting of the Illinois State Bar Association. *Chicago, 1912.* Gift of Illinois State Bar Association.

Saw Mills, their arrangement and management, M. P. Bale. ed. 4. *London, 1914.*

Science of Knitting, Ernest Tompkins. *New York, 1914.*

Spur and Bevel Gearing. *New York, 1914.*

Surge Tank Problems, Franz Prasil. *Toronto, 1914.* Gift of E. R. Weinmann.

Testing of Wood Pulp, Sindall and Bacon. A Practical Handbook for the Pulp and Paper Trades. *London, 1912.*

Tufts College. Announcement of the Engineering School, 1914-15. *Tufts College, Mass., 1914.* Gift of Tufts College.

Der Verkehr. Jahrbuch des Deutschen Werkbundes, 1914. *Jena, 1914.*

Welding. Instruction Paper, George W. Cravens. *Chicago, American School of Correspondence, 1914.* Gift of author.

Covers all forms of welding, blacksmiths' welds, brazing, soldering, gas welding, electric welding, etc. A useful little manual. W. P. C.

Zeitschrift für Physikalische Chemie. vols. 1-82. *Leipzig, 1887-1913.*

——— Namen und Sachregister. vols. 1-50. *Leipzig, 1903-04, 1910-11.*

GIFT OF AMERICAN SOCIETY OF CIVIL ENGINEERS

Association of Ontario Land Surveyors. Annual Report, 1913, 1914.

Canada. Department of the Interior. Report of Progress of Stream Measurements. 1912.

Canada. Department of Railways and Canals. Canal Statistics for the season of Navigation. 1912.

Canada. Department of Public Works. Ottawa River Storage. Progress Report. 1909-1910.

——— Reports of the Ottawa River Storage and Geodetic Levelling from Halifax, N. S., to Rouses Point, N. Y. vol. II, 1912.

——— Reports of the Ottawa River Storage and notes on a visit to the Panama Canal, also Geodetic Levelling between Stephens, Minn., and Winnipeg Beach, Man. vol. II, 1913.

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GIFT OF C. W. RICE

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E. E. Keller
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Terms expire December 1916
George W. Dickie
Henry Hess
James E. Sague

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Terms expire December 1915
Morris L. Cooke
W. B. Jackson
H. M. Leland

Terms expire December 1916
A. M. Greene, Jr.
John Hunter
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Terms expire December 1917
Charles T. Main
Max Toltz
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Carnegie Inst. of Tech.	Oct 14, 1913	W. Trinks	J. B. Patterson	Julius Guter 303 Dithridge St., Pittsburgh, Pa.
Case School of Applied Science	Feb 14, 1913	F. H. Vose	L. W. Hodons	Burton S. Dake 1886 E. 75th St., Cleveland, O.
Columbia Univ.	Nov 9, 1909	Chas. E. Lucke	H. F. Allen	A. S. Henry 333 Central Park W., New York, N. Y.
Cornell Univ.	Dec 4, 1908	R. C. Carpenter	J. G. Miller	W. W. Robertson, Jr. 6 South Ave., Ithaca, N. Y.
Kansas State Agri. College	Feb 13, 1914	A. A. Potter	J. E. Bengston	L. A. Wilsey P. O. Box 564, Manhattan, Kan.
Lehigh Univ.	June 2, 1911	P. B. de Schweinitz	A. V. Bodine	H. A. Brown Lehigh Univ., South Bethlehem, Pa.
Leland Stanford Jr. Univ.	Mar 9, 1909	W. F. Durand	J. A. Gibb	C. L. Addleman 219 Ramona St., Palo Alto, Cal.
Mass. Inst. of Tech.	Nov 9, 1909	E. F. Miller	F. G. Purinton	H. E. Morse Box 233, East Bridgewater, Mass.
New York Univ.	Nov 9, 1909	C. E. Houghton		
Ohio State Univ.	Jan 10, 1911	Wm. T. Magruder	R. D. Rogers	P. W. Sheatsley 1778 E. Main St., Columbus, O.
Penn. State College	Nov 9, 1909	J. P. Jackson	C. F. Kennedy	D. E. Hewitt Box 276, State College, Pa.
Poly. Inst. of Brooklyn	Mar 9, 1909	W. D. Ennis	M. Van Valkenburgh	Samuel Kobre Poly. Inst. of Brooklyn, Brooklyn, N. Y.
Purdue Univ.	Mar 9, 1909	G. A. Young	S. A. Peck	T. S. Tulien c/o Purdue Univ., Lafayette, Ind.
Rensselaer Poly. Inst.	Dec 9, 1910	A. M. Greene, Jr.	C. P. Brown	W. Kelly 374 Clinton Ave., Albany, N. Y.
State Agri. College (Colo.)	Oct 9, 1914	J. W. Lawrence	A. T. Johnson	T. H. Sackett State Agri. College, Fort Collins, Colo.
State Univ. of Iowa	Apr 11, 1913	R. S. Wilbur	L. A. White	H. C. Doane Newton, Ia.
State Univ. of Kentucky	Jan 10, 1911	F. P. Anderson	M. Brooke	T. R. Nunan 345 S. Limestone St., Lexington, Ky.
Stevens Inst. of Tech.	Dec 4, 1908	Alex. C. Humphreys	G. F. Blixt, Jr.	Barton V. Hilliard 531 River St., Hoboken, N. J.
Syracuse Univ.	Dec 3, 1911	W. E. Ninde	W. C. Dexter	G. E. Furbush 718 Irving Ave., Syracuse, N. Y.
Throop College of Tech.	Nov 13, 1914	W. H. Adams	R. O. Catland	H. A. Black 32 N. Grand Oaks Ave., Pasadena, Cal.
Univ. of Arkansas	Apr 12, 1910	B. N. Wilson	M. McGill	C. Bethel Univ. of Ark., Fayetteville, Ark.
Univ. of California	Feb 13, 1912	Joseph N. LeConte	A. C. Moorhead	H. L. McLean Univ. of Cal., Berkeley, Cal.
Univ. of Cincinnati	Nov 9, 1909	J. T. Faig	J. W. Dollman	A. J. Langhammer 713 Crescent Ave., Covington, Ky.
Univ. of Colorado	Apr 10, 1914	P. S. Rattle	L. J. Brady	S. S. Cooke 1089 13th St., Boulder, Colo.
Univ. of Illinois	Nov 9, 1909	W. F. M. Goss	H. E. Austin	E. Gehrig Univ. of Illinois, Urbana, Ill.
Univ. of Kansas	Mar 9, 1909	P. F. Walker	O. T. Potter	I. W. Clark 1212 Louisiana St., Lawrence, Kan.
Univ. of Maine	Feb 8, 1910	Arthur C. Jewett	W. L. Wark	H. A. Titcomb Phi Kappa Sigma House, Orono, Me.
Univ. of Michigan	Apr 10, 1914	John R. Allen	R. H. Mills	C. H. McClellan 928 Oakland Ave., Ann Arbor, Mich.
Univ. of Minnesota	May 12, 1913	W. H. Kavanaugh	J. A. Colvin	J. L. Hartney 1410 Fifth St., S. E., Minneapolis, Minn.
Univ. of Missouri	Dec 7, 1909	H. Wade Hibbard	L. L. Leach	P. R. A. Nolting 615 Turner Ave., Columbia, Mo.
Univ. of Nebraska	Dec 7, 1909	J. D. Hoffman	D. W. Watkins	L. L. Westling Station A, Lincoln, Neb.
Univ. of Wisconsin	Nov 9, 1909	H. J. Thorkelson	M. A. Cook	
Washington Univ.	Mar 10, 1911	E. L. Ohle	R. V. Henkel	E. C. Schisler Washington Univ., St. Louis, Mo.
Worcester Poly. Inst.	June 16, 1914	Ira N. Hollis	W. H. Crippen	H. P. Fairfield Worcester Poly. Inst., Worcester, Mass.
Yale Univ.	Oct 11, 1910	L. P. Breckenridge	R. F. Frost	W. S. Snead 96 Wall St., New Haven, Conn.